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PRELIMINARY SCREENING FOR POTENTIAL ALGICIDES

C. MERVIN PALMER AND THOMAS E. MALONEY

Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio

The search for new and more efficient bactericides, fungicides, insecticides, and herbicides has become increasingly extensive and intensive. Special laboratories have been established for the continuous screening of chemicals for evidence of their toxicity to the various living organisms. The quest for algicides, however, has lagged far behind. This is due, in part, to the lack of any routine procedures for culturing algae which could be utilized in a screening process. Any investigation on mixed growths of algae is difficult to evaluate and virtually impossible to duplicate. While it is recognized that experiments with unialgal cultures cannot replace final tests in the field, it is essential that such cultures be employed for rapid screening tests and for investigations where variable factors must be held to a minimum.

The demand for both general and selective algicides is becoming more definite as technicians and officials connected with water treatment plants increase their interest in controlling algae responsible for various nuisance problems. In more and more situations it is becoming desirable to control or destroy particular kinds of algae while, at the same time, permitting other useful or non-troublesome types to remain unaffected. It is not economically sound to waste an algicide on many species of algae or to destroy the whole biota when destruction of only one species is desired.

Copper sulfate and chlorine have long been the only algicides used extensively in water supplies (American Water Works Association, 1950). With algicides, even more so than with bactericides and fungicides, cheapness is a very important factor, since the algicide has to be used in large quantities to treat the entire water supply. It is difficult, therefore, to discover new materials which can compete with copper sulfate and chlorine in this respect.

NEW ALGICIDES

The increasing interest in new algicides has caused a number of research centers in educational and industrial institutions to undertake a search for new chemicals that may be selected for widespread use (Bowser, 1951; Williams *et al.*, 1952). Announcement of the effectiveness of 2.3 dichloronaphthoquinone in the control of bloom forming blue-green algae is a good example (Fitzgerald *et al.*, 1952). Journals concerned primarily with the care of swimming pools, cooling tanks, farm fishponds, and other bodies of water are now beginning to carry announcements and advertisements of special algicides with various materials as the active agents.

The present need is to develop satisfactory techniques for the discovery and evaluation of chemicals with algicidal properties. In addition, a mass of experimental data is required before the screening tests can be steered into the most promising channels. With this in mind, the staff at the Robert A. Taft Sanitary

Engineering Center has experimented with laboratory cultures of algae in developing a procedure for determining the toxicity of various types of chemicals to algae.

The testing procedure involves a preliminary screening of each chemical against a few algal cultures which is then followed by a more extensive laboratory and field study of the most effective chemicals. In addition, before new algicides can be recommended for use, it is necessary to give consideration to a number of other important factors such as the toxicity of the potential algicides to fish and mammals, their cost, availability, ease of handling, and stability.

The results reported in this paper are limited to the preliminary screening tests, where each chemical is used at only one concentration and against only six cultures of algae. A report on the more extensive tests will be available later.

PROCEDURE FOR SCREENING

For the preliminary screening, the chemicals were tested at a concentration of 2 p.p.m. of the gross materials (except where otherwise indicated). For the most part, the chemicals selected for testing were those with a history of toxicity to plants or animals and especially to microorganisms. A number of the compounds tested are available commercially as fungicides, bactericides, herbicides, and insecticides.

The six representative cultures of algae which were selected for the preliminary screening tests included *Cylindrospermum licheniforme* B. and F. and *Microcystis aeruginosa* Ktz. representing the blue-green algae (Myxophyceae), *Scenedesmus obliquus* (Turp.) Ktz. and *Chlorella variegata* Beijerinck representing the green algae (Chlorophyceae), and *Gomphonema parvulum* (Ktz.) V. H. and *Nitzschia palea* (Ktz.) W. Smith representing the diatoms (Bacillarieae). In a few cases *Gloeocapsa dimidiata* (Ktz.) Dr. and D. was substituted for the closely related *Microcystis aeruginosa*. All cultures used were unialgal and were selected for their ability to produce rapid and uniform growth under laboratory conditions.

The culture medium approximated Gerloff's modification of Chu No. 10 with the amount of nitrate doubled (Palmer and Maloney, 1953). Tests were carried out in 25 ml. Erlenmeyer flasks and incubated at a constant temperature of 22° C in an illuminated culture room (Palmer, 1952). Sterile, double strength medium was inoculated with a small amount (one-fifteenth to one-thirtieth by volume) of an actively growing culture of the alga. A 7.5 ml. portion of this inoculated medium was then combined with a like quantity of distilled water containing 4 p.p.m. by weight, in the case of solids, or 0.0004 percent by volume in the case of liquids, of the chemical to be tested. This resulted in a final chemical concentration of 2 p.p.m. (or 0.0002%) in normal strength medium and with an inoculum of one-thirtieth to one-sixtieth the volume of the original algal culture. The number of algal cells in the test medium at the beginning of the test was comparatively small, averaging approximately 125,000 per ml.

During the period of incubation, the amount of visible algal growth was recorded at specified intervals for a total of 21 days. Growth was then compared with that in the control flasks containing 15 ml. of normal strength inoculated culture medium but no test chemical. The results for each chemical were then recorded under the following headings:

Toxic (T) Where no growth occurred in the presence of the test chemical, but did occur in the control flask.

Partially Toxic (P) Where growth occurred in the presence of the test chemical, but the amount was not as great as that in the control flask.

Non-Toxic (N) Where growth in the presence of the test chemical was similar in amount to that in the control flask.

Stimulant (S) Where growth in the presence of the test chemical was greater in amount than that in the control flask.

RESULTS

The results of the research are summarized in table 1 and show, for each test chemical, the relative toxicity (T, P, N, S) evident after incubation periods of 3, 7, 14, and 21 days for each of the six cultures of algae. The table shows results obtained with a total of 76 test chemicals, including such well known compounds as copper sulfate, calcium hypochlorite, mercuric acetate, 2,4 dichlorophenoxyacetic acid (2,4-D), 2,3 dichloronaphthoquinone, tetrachlorophene, benzene hexachloride, 3-(p-chlorophenyl) -1, 1-dimethylurea (CMU), rosin amine D acetate (RADA), and streptomycin. The 76 compounds are arranged in ten groups, based upon their chemical composition and structure. Chemicals preceded by an asterisk were obtained as commercially advertised toxic products (insecticides, herbicides, algicides, bactericides, and fungicides).

TABLE 1

Toxicity of Chemicals to Algae

	Cylindrospermum				Microcystis				Scenedesmus				Chlorella				Gomphonema				Nitzschia			
PERIOD OF INCUBATION (IN DAYS)	3	7	14	21	3	7	14	21	3	7	14	21	3	7	14	21	3	7	14	21	3	7	14	21
INORGANIC SALTS																								
*Copper sulfate (anhydrous)	P	P	T	T	T	T	T	T	P	P	N	N	T	T	T	T	T	T	T	T	T	T	T	T
*Copper sulfate (with stabilizing agent)	T	T	T	T	T	T	T	T	P	P	P	N	P	P	P	P	N	T	T	T	N	T	T	T
Colloidal silver (33% silver nitrate)	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
*Activated colloidal silver compound	P	P	N	N	P	P	P	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
*Calcium hypochlorite	T	P	N	N	T	T	T	T	T	P	N	N	T	T	T	T	T	T	T	T	T	T	T	T
Sodium chloride	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
ORGANIC SALTS																								
*Disodium copper salt of ethylene diamine-tetra acetic acid (18.25%)	N	N	N	N	N[1]	N	P	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
*Copper salt plus citrate	T	T	T	T	T	T	T	T	P	P	N	N	T	T	T	T	T	T	T	T	T	T	T	T
Copper naphthenate (8%)	N	P	N	N	T	T	T	T	P	N	N	N	P	N	N	N	T	T	P	P	N	N	N	N
*Zinc dimethyl dithiocarbamate (65%)	P	P	N	N	T[1]	T	P	N	N	N	N	N	P	P	P	N	T	T	T	N	T	T	T	T
Zinc dimethyl dithiocarbamate (100%)	T	T	T	T	T	T	T	T	T	T	T	P	T	T	T	T	T	T	T	T	T	T	T	T
*Disodium ethylene bisdithiocarbamate (19%)	N	S	N	N	N[1]	N	P	N	N	N	N	N	T	N	P	N	T	T	T	N	T	T	T	T
*Pentachlorophenate (75%) plus sodium salts of other phenols	P	P	P	P	P	P	P	N	P	P	P	N	N	N	N	N	P	P	N	P	T	P	N	P
*Sodium pentachlorophenate (75%), sodium salts of other phenols	T	T	P	N	T	T	P	N	P	P	N	N	N	N	N	N	P	P	N	N	T	T	N	P
*p—chlorophenyl—p—chlorobenzenesulfamate	P	N	N	N	P	P	P	N	N	P	N	N	N	N	N	N	N	P	N	N	T	P	N	N
Xanthic acid, ethyl sodium salt	N	N	N	N	N	P	N	N	N	N	N	N	P	P	N	N	N	N	N	N	N	N	N	N
*Lauryl isoquinolinium bromide (20%)	T	P	N	N	P	P	P	N	T	T	T	T	P	P	N	N	N	P	N	N	N	P	N	N
Mercuric acetate	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	P	T	T	T	T	T	T	T	T
Phenyl mercuric hydroxide	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Phenyl mercuric nitrate	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
ORGANIC ACIDS																								
Acetic acid	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
4, chloro-o-toloxyacetic acid	T	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	T	P	N	N	T	N	N	N
*2, 4 dichlorophenoxyacetic acid	P	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	T	N	N	N
Iodoacetic acid	P	P	N	N	T	T	T	T	T	T	P	N	N	N	N	N	P	P	P	N	N	N	N	N
*2, 4, 5 trichlorophenoxyacetic acid	S	N	N	N	T	T	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
3 nitro 4 acetoxybenzoic acid	S	S	N	N	S	S	N	N	N	N	N	N	S	S	N	N	S	N	P	P	S	N	N	N
3 nitro 4 hydroxybenzoic acid	S	S	P	P	S	S	N	N	N	N	N	N	N	N	N	N	S	S	P	P	S	N	N	N
3 nitro 4 methoxybenzoic acid	N	N	N	N	P	N	N	N	P	P	N	N	P	N	N	N	T	P	P	P	N	N	N	N

TABLE 1—(*Continued*)

	Cylindrospermum				Microcystis				Schenedesmus				Chlorella				Gomphonema				Nitzschia			
PERIOD OF INCUBATION (IN DAYS)	3	7	14	21	3	7	14	21	3	7	14	21	3	7	14	21	3	7	14	21	3	7	14	21
ALCOHOLS, ALDEHYDES, KETONES																								
4, 4 dichloro-alpha-methylbenzhydrol	P	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	P	P	P	N	N	N	N	N
*Terpine alcohol (85% pine oil)	T	N	N	N	P	P	P	N	N	N	N	N	T	N	N	N	T	N	N	N	N	N	N	N
*di (p-chlorophenyl) methyl carbinol	P	P	N	N	N	N	N	N	T	T	T	T	T	P	N	N	T	T	T	T	T	T	T	T
2, 3 dichloronaphthoquinone	P	P	N	N	T	T	T	T	N	N	N	N	P	N	N	N	T	T	P	N	T	T	T	T
Salicaldehyde	P	N	N	N	P	N	N	N	P	N	N	N	P	N	N	N	T	P	P	P	T	P	P	P
Vanillin	N	N	N	N	N	N	N	N	P	N	N	N	P	N	N	N	T	P	P	P	N	P	N	N
Dimethylaminobenzaldehyde	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
PHENOLS																								
Tetrachlorophene	T	P	N	N	N[1]	N	N	N	P	P	N	N	P	N	N	N	N	N	N	N	T	N	N	N
2 tertiary-butyl-4, 6 dinitrophenol	N	N	N	N	N	N	N	N	N	N	N	N	N	P	N	N	S	N	N	N	N	N	N	P
Dinitro-o-secondary butylphenol	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Picric acid	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
SUBSTUTUTED HYDROCARBONS																								
Benzene hexachloride, alpha isomer	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Benzene hexachloride, beta isomer	P	P	N	N	P	P	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Benzene hexachloride, delta isomer	N	N	N	N	N	P	N	N	P	P	N	N	N	N	N	N	P	T	T	T	P	P	P	N
Benzene hexachloride, gamma isomer	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
*Benzene hexachloride, gamma isomer, tech	N	N	N	N	N	N	P	P	N	N	P	N	N	N	N	N	P	P	P	P	N	N	N	N
Cumene hydroperoxide (commercial)	P	P	N	N	T	T	N	N	N	N	N	N	T	P	N	N	N	P	N	N	T	T	N	N
*Dichloro diphenyl trichloroethane	N	N	N	N	T	T	N	N	N	N	N	N	N	N	N	N	N	P	N	N	N	N	N	N
2-benzoyl 1, 3 dichloropropane (50% active)	T	T	P	P	T	T	T	T	P	P	N	N	T	T	T	T	T	T	T	T	T	T	T	T
*Chlorinated camphene (60%)	P	P	P	P	T	T	T	P	P	N	P	N	N	N	N	N	P	P	P	P	T	P	N	N
*Chlorinated benzene (No. 1)	T	T	T	T	T	T	T	T	T	P	P	P	T	T	T	T	T	T	T	T	T	T	T	T
*Chlorinated benzene (No. 2)	T	T	P	P	T	T	T	T	N	N	N	N	P	N	N	N	T	T	P	P	T	P	N	N
*Chlorinated benzene (No. 3)	T	T	T	T	T	T	T	T	N	P	N	N	P	N	N	N	T	T	T	T	T	T	T	T
*Alkyl aryl bromide, aqueous solution	N	N	N	N	T	T	T	T	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
QUARTERNARY AMMONIUM COMPOUNDS																								
*Methyldodecylbenzyl trimethyl ammonium chloride (50%) 50% H_2O	T	P	N	N	P[1]	N	N	N	T	T	T	N	P	P	N	N	T	T	T	N	T	T	T	N
*Cetyldimethyl ammonium bromide (2%), alkylate ether alcohol (10%), 85% inert	N	N	N	N	N[1]	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
*Dodecylacetamido dimethyl benzyl ammonium chloride (100%)	P	P	P	N	T[1]	P	P	N	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
*High molecular alkyl-dimethyl-ammonium chlorides (10%)	P	P	N	N	N[1]	N	N	N	N	P	N	N	P	N	N	N	N	N	N	N	P	N	N	N
*Mixed trimethyl and trimethyloctadecadienyl ammonium chlorides (25%), 75% H_2O	N	N	N	N	N[1]	N	N	N	N	P	N	N	N	S	N	N	N	N	N	N	N	N	N	N
*Methyl dodecyl benzyl trimethyl ammonium chloride plus tridecyl methyl hydroxy ethyl imidazolinium chloride (10%), 90% H_2O	N	N	N	N	N	N	N	N	P	P	P	N	P	P	N	N	N	N	N	N	N	N	N	N
AMINES, AMIDE DERIVATIVES																								
Alpha naphthylamine	N	P	N	N	T	T	T	T	P	P	N	N	T	P	N	N	T	T	P	P	T	P	N	N
Beta naphthaquinoline	P	P	P	P	N	N	N	N	P	P	P	P	P	P	N	N	T	T	P	P	T	P	N	N
2, 4 dinitrophenylhydrazine	N	N	N	N	N	N	N	N	N	N	N	N	N	P	N	N	N	N	N	N	N	N	N	N
Thiocarbamide	N	N	N	N	P	P	P	N	P	P	P	N	N	P	N	N	P	P	N	N	P	P	N	N
*3—(p—chlorophenol)—1, 1—dimethylurea	P	P	T	T	T	T	T	T	T	T	P	P	T	P	P	N	P	P	P	T	T	T	T	T

TABLE 1—(*Continued*)

	Cylindrospermum				Microcystis				Scenedesmus				Chlorella				Gomphonema				Nitzschia			
PERIOD OF INCUBATION (IN DAYS)	3	7	14	21	3	7	14	21	3	7	14	21	3	7	14	21	3	7	14	21	3	7	14	21
ROSIN AMINE COMPOUNDS																								
*Rosin amine D acetate (50% solution)	T	T	T	T	T	T	T	T	P	P	N	N	T	T	T	T	T	T	T	T	T	T	T	T
*Rosin amine D sulphate, wettable powder (75% active)	T	T	T	T	T	T	T	T	T	T	T	P	T	T	T	T	T	T	T	T	T	T	T	T
Diethanol rosin amine D acetate (70% active)	T	T	T	T	T	T	T	T	N	P	P	P	T	T	P	N	T	T	T	T	T	T	T	T
Emulsifiable rosin amine D (85% active)	T	T	T	T	T	T	T	T	T	P	P	N	T	T	T	T	T	T	T	T	T	T	T	T
Emulsifiable rosin amine D pentachlorophenate (40% active)	T	T	P	N	P	P	P	N	N	N	N	N	T	T	N	N	T	T	P	N	T	T	T	T
Sodium carboxyethyl rosin amine (10% solution)	N	N	P	N	P	P	P	N	N	N	N	N	N	N	N	N	T	N	N	N	N	N	N	N
Emulsified rosin amine derivative (40% active)	P	P	N	P	T	T	P	N	P	P	P	P	P	N	N	N	T	T	T	T	T	T	T	T
N (3—aminopropyl) rosin amine D diacetate (28% active)	T	T	T	P	T	T	T	T	P	P	P	P	T	T	T	P	T	T	T	T	T	T	T	T
ANTIBIOTICS																								
*Acti-dione	P	P	N	N	N	N	N	N	T	T	T	T	T	P	N	N	N	T	T	T	T	T	T	T
*Aerosporin-Polymyxin B (sulfate)	P	P	T	T	T	T	T	T	T	T	T	N	T	T	T	T	T	T	T	T	T	T	T	T
*Penicillin G, potassium (crystalline)	P	P	N	N	T	T	T	T	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
*Streptomycin sulfate	T	T	T	T	T	T	T	T	P	P	T	T	N	N	N	N	N	N	N	N	N	T	T	T
*Terramycin	P	P	N	N	T	T	T	T	N	N	N	N	N	N	N	N	N	N	N	N	T	P	N	N

*Obtained as commercial product
T Toxic
P Partially toxic
N Non-toxic
S Stimulant
N[1], P[1], T[1] *Gloeocapsa* substituted for *Microcystis*

Comparative Toxicity of Chemical Groups

Four of the ten groups of chemicals are outstanding in containing several chemicals which were toxic to the algae. These groups are the Inorganic salts, Organic salts, Rosin amine compounds, and Antibiotics. Many of the other groups contain individual compounds which are also toxic to the algae at a concentration of 2 p.p.m.

Copper sulfate and calcium hypochlorite, which are representatives of the first group, proved to be toxic, or at least partially toxic to all six of the test algae. Both were less effective against *Scenedesmus* than they were against the other genera of algae. This is in agreement with the statement by Bussy (1949) that *Scenedesmus obliquus* is highly resistant to copper sulfate and chlorine.

Another representative of group one, colloidal silver (33% silver nitrate), was highly toxic to all six of the algae. However, in a commercial preparation of an activated colloidal silver compound, there was relatively no toxic effect. This could be due, in part, to the difference in the concentrations of the active ingredients of the two compounds. Sodium chloride had no inhibitory effect on any of the six algae.

Among the Organic salts, the mercuric compounds were highly toxic to the algae. However, they are relatively high in cost and their probable toxicity to animals may limit their possible usefulness as algicides. The copper salt and citrate mixture was toxic to all of the test algae except *Scenedesmus*. This formulation would not appear, however, from these preliminary tests to be of any advantage over copper sulfate when used alone. A 2 p.p.m. concentration of zinc dimethyl dithiocarbamate was toxic to the six test algae while a commercial

preparation, which is recommended as a fungicide, containing 65 per cent of this compound was toxic to only three of the algae. The two pentachlorophenate compounds had some effect on every alga except *Chlorella*, but no marked effect in any case. Lauryl isoquinolinium bromide differed from the others in that it was selectively toxic to *Scenedesmus*.

As stated above the Organic acids, as a group, had little effect on the six algae. Additional study might be warranted in the case of iodoacetic acid as a possible algicide for *Microcystis* and its related forms. It appeared to have relatively the same toxicity as 2,3 dichloronaphthoquinone which has already been described (Fitzgerald *et al.*, 1952) as a promising algicide.

Of the ten groups, the Phenols were the least toxic to the algae. One compound, tetrachlorophene, was capable of temporarily preventing or reducing growth of four of the six algae. However, within one or two weeks this initial toxicity had been overcome.

The compounds in the group listed as Alcohols, Aldehydes, and Ketones were sporadic in their toxic effects and none of the compounds appeared to be outstanding in their algicidal properties.

Four isomers of benzene hexachloride are included in the group listed as Substituted hydrocarbons. The delta isomer was the only one of these which exhibited much toxicity. It was toxic to *Gomphonema* and partially toxic to *Nitzschia*. The compound 2- benzoyl -1,3 dichloropropane (50%) displayed some toxicity to all six algae. This was only a partial effect in the case of *Scenedesmus* and its growth returned to normal after two weeks. Chlorinated camphene (60%) had some toxic effect on all the algae except *Chlorella*. However, the only pronounced effect was against *Microcystis*. The three chlorinated benzene compounds were in fair agreement in their toxicity to the six algae. One, however, did prove to be toxic to *Chlorella* while the others did not. The aqueous solution of alkyl aryl bromide was selectively toxic to *Microcystis*.

One of the Quaternary ammonium compounds, dodecylacetamido dimethyl benzyl ammonium chloride, showed greater toxicity to the green algae than to the blue-green algae. This is of particular interest because, in general, the green algae were found to be resistant to most of the tested chemicals.

The dimethylurea compound listed in the eighth group, Amines and Amide derivatives, was toxic to all six algae. In two cases the effect became more intensified after prolonged incubation.

The Rosin amine compounds were highly toxic to the test algae at 2 p.p.m. of the gross concentration. The least effective formulation may have been so as a result of its low percentage of active ingredients. Lawrence (1954) reports dehydroabietylamine acetate (Rosin amine D acetate), at 0.5 p.p.m. of the active ingredient, to be toxic to the filamentous green alga, *Pithophora*, and non-toxic to phytoplankton, but the particular genera of the organisms comprising the phytoplankton are not given.

Among the Antibiotics, polymyxin was clearly the most toxic to the algae. Algal growth was prevented in most cases, for the total incubation period of 21 days. Results with streptomycin confirm previous studies (Foter *et al.*, 1953) which indicate that it is particularly effective against blue-green algae.

Comparison of Effects on Each Alga

For a minimum of three of the four observation periods during incubation, a total of 26–29 of the chemical compounds prevented growth of *Microcystis*, *Nitzschia*, and *Gomphonema*. For the remaining three algae this same condition was limited to 12–16 chemicals. It is evident, therefore, that the blue-green alga, *Microcystis*, and the two diatoms, *Gomphonema* and *Nitzschia*, were much more sensitive to the various chemicals than were the other blue-green alga, *Cylindrospermum*, and the two green algae, *Scenedesmus* and *Chlorella*.

In general, the two diatoms reacted somewhat alike to the test chemicals. The results with the Organic salts, zinc dimethyl dithiocarbamate (65%) and disodium ethylene bisdithiocarbamate (19%) as well as with the substituted hydrocarbon, benzene hexachloride, delta isomer, would indicate that they may be selective for diatoms. Streptomycin sulfate was the only substance which was decidedly toxic to *Nitzschia* and non-toxic to the other diatom, *Gomphonema*.

The two green algae tested were frequently alike in their reactions to the chemicals. Exceptions to this are evident in the cases of copper sulfate, copper salt plus citrate, calcium hypochlorite, 2-benzoyl, 1,3 dichloropropane (50%), chlorinated benzene (No. 1), and some of the Rosin amine compounds where *Scenedesmus* was more resistant than *Chlorella*. *Chlorella*, on the other hand, was more resistant than *Scenedesmus* to lauryl isoquinolinium bromide (20%), di(p-chlorophenyl) methyl carbinol, methyldodecylbenzyl trimethyl ammonium chloride (50%), and acti-dione.

The two blue-green algae which were used, in contrast to the green algae and diatoms, were extremely different from one another in their reactions to the test chemicals. *Microcystis* proved to be much more sensitive than *Cylindrospermum*. The following substances were selectively toxic to *Microcystis:* copper naphthenate (8%), iodoacetic acid, alpha naphthylamine, chlorinated camphene (60%), penicillin and terramycin. Tetrachlorophene appeared to be temporarily toxic to *Cylindrospermum* and non-toxic to *Microcystis*.

Additional Observations and Comments

A distinct initial stimulation in the growth of most of the algae was noted in the flasks containing a concentration of 2 p.p.m. of the Organic acids, 3 nitro 4 acetoxybenzoic acid and 3 nitro 4 hydroxybenzoic acid. A closely related compound, 3 nitro 4 methoxybenzoic acid, produced no stimulation and was partially toxic to 4 of the 6 algae.

The length of the period of incubation is an important consideration in determining the effects of the chemicals on algal cultures. For all six of the test algae the number of substances toxic to them in the short observation periods was greater than that for the longer periods. With *Chlorella*, for example, 25 chemicals were toxic to the alga for 3 days, but only 14 were effective in preventing growth up to 21 days. However, this difference was much less for the blue-green algae.

Up to the present time there are few data available to determine whether or not insecticides, herbicides, bactericides, and fungicides may also be effective algicides. The dimethylurea formulation which is listed as a universal herbicide, was toxic to the algae at the concentration employed. Two other herbicides, 2,4,5 trichlorophenoxyacetic acid and 2,4 dichlorophenoxyacetic acid had little or no effect on the six algae. Most of the insecticides tested had little effect on the algae, the chlorinated camphene probably being the most toxic of the group.

Bactericides and particularly fungicides may be more toxic to algae than are many of the pesticides. Some of these, such as acti-dione, 2,3 dichlonaphthoquinone, and the quaternary ammonium compound, dodecylacetamido dimethyl benzyl ammonium chloride, were selective in their action and may form types from which selective algicides could be developed.

It is important to emphasize the fact that the results reported here are based upon a certain procedure involving the use of 2 p.p.m. of the gross concentrations of chemical substances being tested, the addition of the chemical at the time of inoculation with the algae, the use of six specific cultures of algae, and the employment of a single culture medium having a relatively high pH. The modification of any of these or other factors could produce results differing greatly from those which are reported here.

In later studies it is planned to modify certain of the more important factors

and to determine which ones may be of particular significance in effecting the screening tests.

SUMMARY

A comparatively simple procedure for the preliminary screening of chemical compounds for algicides is described together with results obtained with the first 76 substances tested.

As groups, inorganic and organic salts, rosin amine compounds, and antibiotics tended to show high toxicity to the six test algae at gross concentrations of 2 p.p.m.

A number of the tested substances exhibited selective toxicity to one group of algae or to one particular alga.

In general, the algae most sensitive to the test chemicals were the blue-green alga, *Microcystis*, and the two diatoms, *Nitzschia* and *Gomphonema*. The algae most resistant to the test chemicals were the green algae, *Scenedesmus* and *Chlorella*, and the blue-green alga, *Cylindrospermum*.

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North American Prairie. *John E. Weaver.* Johnsen Publishing Co. Lincoln, Nebraska xi + 348 pp. $5.00.

Probably no individual in the half-century history of ecology in North America has studied the grasslands so long or so intensively as Dr. Weaver. Certainly, even if their rate of destruction were halted, no one ever will do as much again.

In addition to his own findings and those of his students he has incorporated the major contributions of others in this work. If there are omissions, Historian J. C. Malin's is probably the most significant.

One ventures the opinion that this book will last long and be always a standard reference to those whose view of Tall Grass Prairie will of necessity be through the eyes of Dr. Weaver.

The author's style is refreshing, lucid, and has the golden touch of a writer who has loved the landscape he has worked and lived in for 40 summers. The story was written at the time his field studies were under way and the reader can sense the intimate feeling he has for the grassland.

There are 16 chapters, dealing with the dominant grasses and associated herbs, their roots and rhizomes, the communities they form, soil relationships, drouth, degeneration, destruction and/or recovery, seasonal aspect, and numerous other topics. He has attempted "to write a simple, coherent story of the prairie, scientifically accurate, but in non-technical language for the general reader"; and "to bring together the findings of other workers." He has succeeded in both objectives in language of uncommon beauty.

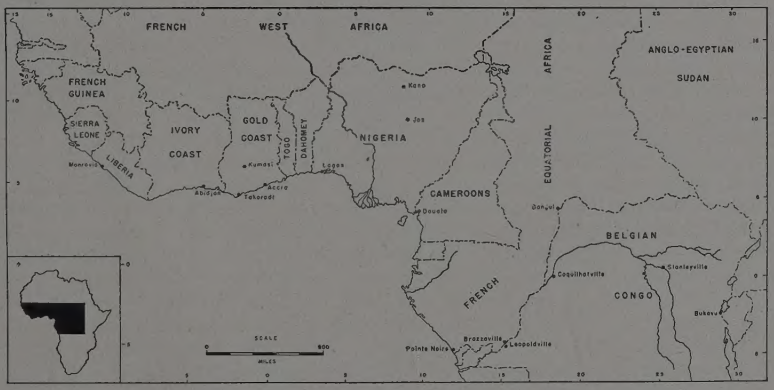
JOHN N. WOLFE.

THE PROGRESS OF NATIONALISM IN WEST AFRICA[1]

RODERICK PEATTIE

Department of Geography, The Ohio State University, Columbus 10

There is always the possibility, of course, of a complete and thorough democratic nationalism in West Africa. Will it be achieved in a short period or will it never be attained? Recently I traveled in West Africa to ascertain what were the factors for or against such attainment. I read freely in the field and in reading found two types of writing; one of the imperialistic type writing about the African as a white man's burden and given little space to the African's opinions and the other dealing with the aroused sentiments of the black man and often written by Africans themselves. As a result of my reading I presume I went on my journey with a pre-conceived notion that to an extent at least the West African was growing up politically and spiritually but at a different rate under the various political regimes and his stature was far less than the requirements put upon him by modern civilization.



I must correct these opinions in part. The leaders among the Africans are highly intelligent, though at times their judgments are governed by their emotions. The men are educated in French, British and American universities and have a greater political maturity than the average student because they came to the universities with a definite purpose. But once again in their homeland and assuming their leadership they are faced with a number of difficulties. First, back of the coast is a zone reaching to a maximum of two hundred miles which is covered by rainforest. Upon this modern ideas break and have great difficulty in penetrating, and there are millions of natives living without sufficient contacts with western democratic worlds. Good roads can in part overcome the difficulty and there are some trunk roads into the interior. But three, five or ten miles at right angle to the roads the villages are still primitive—the villages and the ideas of men. True, the life in the more primitive villages which has little contact with the white civilization may have a well-disciplined life of an ancient African

[1]The expenses of the trip were in part borne of the Research Foundation of the Ohio State University.

culture but mostly the men of the villages have just enough contact to acquire the white man's gin bottle. Read Joyce Cary's "Mr. Johnson" to understand what extent has the African taken on the ways of the Britisher in Nigeria.

By roads built there is better education of the African and he is intensely eager for his training. It is not for an immediate uplift for the economic situation, a bigger income, but something far greater that attracts him. He realizes that greater education is the hope of his race. The primary education has been carried on mainly by the missionaries, first in the vernacular and later in European languages. There are institutions of secondary education and technical schools and a few colleges and institutions, some partly supported by missions and partly by the governments. There are always more applicants than can be accepted. But the intelligent student is seldom sufficiently trained and there are few who are able to carry on the work of education of the masses. And the masses of people in the back country are in overwhelming numbers. If nationalism grows apace it will outdistance the educational schemes. Imperialism will be set aside by nationalism long before the Africans can depend on their own efforts in education and, indeed, in civilizing the back country. Higher and the more technical phases of education will for the immediate future be in the hands of the white man.

One type of mission work is being practiced to a greater or lesser degree in various regions. It is of founding areas in the interior, after among the most primitive peoples, of communities which teach western ways of life, their situation, improved agriculture, industry and literacy. I visited one notable community which was founded by George Way Harley under Methodist auspices in 1926 in the interior of Liberia, indeed 200 miles from Monrovia by rough trail. Harley went prepared to teach brick and tile making, lumbering and wood working, sanitation, schooling, medicine (he was a doctor), and, of course, Christianity. He built the first wheel in the back country. Emory Ross, who knows Africa thoroughly, in his *African Heritage* tells of a going experiment in Angolo. It was begun in 1909. Gradually the direction has taught a new approach to the land, one that stresses good health, literacy community organization, recreation, seasonal festivals, family life, music and worship. The result is that they are receiving material goods and western ideas and ideals of good self-government. There are many other examples of civilizing work by the missions in the lands of West Africa.

Particularly the missions must remain because the African has not arrived at a state of spiritual maturity. I asked the question of Dr. Schweitzer as to the spiritual maturity and he was quite right in saying the African was very far from the goal. On the other hand, I would have obtained slightly different answer from the neighboring missions nearby where they were working to that end. The African has learned to govern himself in part but mainly, in the case of the under officials, through corrupt methods.

There is another feature important in nationalism for the African. This is the urbanization which is sweeping the continent and amounting to a revolution of the former simple ways of the native. Under his bucolic regime he was guided by the elders of the tribe or village, under their regulations and disciplines. In recent years a great many of the young men have flocked to the rapidly growing cities, so many that the population statistics are incorrect as soon as they are published. The new influx of men from the countryside permits them to think more freely about political matters but also permits a great deal of corruption and immoral thinking. It has undermined many of the Africans until they are far from being spiritually ready for a political independence. They would seem to be hardly ready for an expression of nationalism. But there are the separate regimes imposed from above under which the African has advanced at different rates.

In the Belgian Congo we have an example of the best run colony from the point of view of the imperialist. It is on the surface a country of content. The

native is given a chance to rise to a position of a white collar clerk or a skilled workman and he is essentially an *evolué*, a superior African, who has special living quarters and is under no color bar theoretically. But actually yes. He dares not go to the hotels. Furthermore he was not educated in a higher sense of the word until recently. There are a handful now permitted a higher education. Actually the Belgians are worried lest he be educated politically and, that it is figured the Belgians can maintain the color superiority for thirty years more. The land is essentially run by huge corporations or wealthy individuals which own concessions. But no agricultural concession owned by a corporation or an individual may operate without establishing medical dispensaries and schools. Also the Roman Catholic Church is in charge of the public schools and is doing the task very well. And the great mining corporation of the Katanga Region, which I have not seen in operation, is performing a task of a complete social science among its workers and it is a highly intelligent program. Personally, I have seen the native mistreated. The individual, at least in cases, will have an attitude toward the black man which does not speak for a continued happy relation.

The French have used a different method of raising the African to a higher political status. They are permitting individuals when they have acquired enough of French culture to become Frenchmen, *evolués*, black citizens of France. Some of them move to France where they are happier or on staying in their homeland assume a superior tone in their way of living. They are free of a color bar and, indeed, may have a greater bar between them and the other Africans than exists between them and the French. The French are forcing the *evolués* to accept a ready-made nationalism instead of permitting them to erect one of their own in which they would take a great pride. I am inclined to think that the Africans of French territories look wistfully upon the British subjects who have achieved or are struggling to achieve a near-completion of their nationalism. But in French Equatorial Africa there is a large jungle to strive against. Vast areas are very slightly populated. The mass of people can not be reached so isolated are they in the deep forest. And the French are endeavoring to give a program of human rights, as conceived in France, to the African and the imperialists experience a sense of moral rectitude thereby. According to Emory Ross it is impossible to pass on a concept of human rights. You can only educate people to a stage where they will evolve a program of human rights as they conceive them. But the French are fearful of self-government by the African.

Nigeria is a land which has gone far in transportation having a network of roads, many of them well paved trunk lines and two railroads crossing in the middle courses. Also British agents and the British and American missionaries have been there so long and have been so active that the Nigerians are many of them educated up to and some beyond the eighth grade. Some of them have gone to British and American universities and recently their own university. The British are doing an excellent and disinterested task. They are finally aware of their progress of nationalism and what it means but because of tribal and regional disagreements are hardly ready for it. The Gold Coast is inhabited mainly by related tribes who have been well educated for a considerable time. But both the Nigerians and the Gold Coasters have regulations which are aids to political independence. They do not allow the white man to own any considerable land—there are no plantations of size or concessions. This is very important. The palm oil, cotton, peanuts and cacao are grown on two to four acres under peasant farmers.

Lastly there is Liberia. Until recently they were under an imperialistic system, the imperialists being the Americo-Liberians, most who had never been on Liberian soil until they came as conquerors. But today's nationalism is because they were convinced that by a strong political reformation they would take their place among the free nations of the world.

But, in spite of my contact with many Africans eager to begin self-government and capable of it, I still remember the inefficiency and perhaps the corruption of the police in Monrovia. I remember many times when a European had to fairly shout directions out to a servant to be sure he understood it. The Africans are cheerful as servants but at times I believe them to be amoral. And I think of numerous tales when a man or a woman without relatives is in danger of being eaten. Indeed, I know of a missionary in the back country for many years to have never known a native who has been buried. Christianity is then the beginning of civilization. Yet at another mission conversion was slow because men who adopted the teaching were in danger of having their skins hung on a wall.

This of course, is far in the interior where civilizing movements have just begun. But the Africans in the coastal towns in accomplishing national liberty will have a difficult time in teaching the people of the hinterland, the principles of democratic nationalism.

Principles of General Ecology. *Angus M. Woodbury.* The Blakiston Co., Inc. New York. 1954. viii + 503 pp. $6.00.

This book is about adaptations—plant and animal. The author explains how they came about and what they're good for in anthropomorphic language not matched in the last half century of technical ecological writing in North America.

Where statements are not directly teleogical, the mode of thought is often implied. To those disposed to this point of view, the book is a great repository of information, not all of it true.

The author states (p. 292): "In fact, the flower may be regarded as a signal to the insect that pollen or nectar may be found there." On page 304 he says that, "If two different organisms from different genetic stocks live in the same or similar environment they may develop characters that are more or less superficially similar . . . through divergence from former characters guided by natural selection toward a common objective, that of fitting the same environment." We learn that, "Both flowers and insects have developed adaptations to fit one another"—a truly remarkable concept. Also we are told that "an individual rat will either have to adjust itself to an unsuitable soil, move to a new place, or perish." These are common kinds of statements, beginning on the first page of the introduction where the author refers to the physical environment "which organisms encounter and which they must either avoid or mold to fit their organic needs."

This in view of the author's prefatory remark that, "If anyone reads into the work implications of anthropomorphism, Lamarckianism (in the sense of inheritance of acquired characters) or other unnatural implications, he will be placing interpretations on words not intended by the author . . . the reader has a duty to search for the author's meaning and not misconstrue his intentions."

In this case the reader will likely find his duty tedious and long lasting and the author's intentions quite obscured by anthropomorphic verbosity subsequent to the preface.

Of the 167 figures 42 are photographs, leaving much to be desired as illustrative material. Some of the "tree of life" charts are characterized by inadequate terminology. The bibliography contains over 450 titles.

JOHN N. WOLFE.

The Cultivation of Animal and Plant Cells. *Philip R. White.* The Ronald Press Company, New York. 1954. xi+239 pp. $6.00.

The tissue culturist and his work are frequently cloaked with a mysterious and sacrosanct aura. The cause? In controlling growth, perhaps he feels that he is assuming a small segment of the activities of the Creator. Of course, this is not an intentional attitude. This pleasant little volume, proceeding with the objective that "things are not to be made more complicated than necessary," has no occult elements. The author satisfactorily fulfills his three main objectives—(1) presentation of major techniques for cell culture of plant and animal materials; (2) to make available basic techniques for beginners with no background; and (3) to emphasize the concept of "cell culture" as opposed to "tissue culture" in so far as usual procedures involve cultivation of groups of cells from a "tissue" but not the tissue itself.

Dr. White is well equipped to author this concise volume. It should appeal to the embryonic tissue culturist for whom it was intended.

CLAUDE-STARR WRIGHT AND MATTHEW C. DODD

GROUND-WATER HYDRAULICS AS AN AID TO GEOLOGIC INTERPRETATION[1]

WILLIAM C. WALTON
Hydraulic Engineer, U. S. Geological Survey, Columbus, Ohio

The ground-water hydrologist has at his disposal a number of hydraulic tools that are of value in solving geologic problems. Among these is the aquifer-hydraulics test wherein the influence of pumping, or recharging, a well at a known constant rate is measured at several observation wells tapping the aquifer. From the results of such a test, the water-bearing properties of a rock unit can be evaluated and the location and hydrologic importance of its stratigraphic or structural boundaries can be appraised.

Rocks of the earth's crust serve as vast underground reservoirs for the storage and transmission of ground water. The physical properties and the hydrologic dimensions of the reservoirs differ according to the various geologic processes which contributed to their existence.

Interstices, or openings, in rocks differ widely in character, size and shape. Most are relatively small and permit only slow percolation of ground water. The principles of the occurrence of ground water are discussed in detail by Meinzer (1923) and the reader interested in further details is advised to consult this paper.

THE COEFFICIENT OF PERMEABILITY

The capacity of a formation to transmit ground water is indicated by its coefficient of permeability and is dependent upon the size, shape, arrangement, and assortment of materials, and upon the degree to which these materials have been compacted, cemented, indurated, or otherwise altered by geologic processes.

Field measurements of the permeability of consolidated rocks and unconsolidated deposits are made by means of aquifer-hydraulics tests. Field tests have an advantage over laboratory determinations, because aquifers are appraised in an undisturbed state, whereas laboratory permeability tests are dependent upon results obtained from small cores, or even disturbed samples, of materials which may not be truly representative of the aquifer being tested.

The size of the portion of an aquifer sampled by means of a single aquifer-hydraulics test depends upon the water-bearing properties, the geologic and hydraulic boundaries of the aquifer, and the duration of the test. In an artesian aquifer a 24-hour test may sample a cylinder of water-bearing material having a diameter of 1 mile or more. Under water-table conditions a 24-hour test may sample a cylinder having a diameter of 2,000 ft., or even less. Tests of more than 24 hours duration at several sites are desirable to evaluate properly the hydraulic properties of an aquifer.

The most productive aquifers in Ohio are the glacial valley-train and outwash-plain deposits of sand and gravel. It is possible that the over-all permeabilities of the valley-train deposits differ from valley to valley because of the variable distribution of glacial melt waters to the drainage basins in Ohio. The permeability of the outwash deposits is related to the amount of melt water that was available to rework and sort glacial materials. The permeabilities of valley-train and outwash-plain deposits also change from place to place within a given deposit as a result of variable conditions of deglaciation. Two or more outwash fills separated

[1]Presented at the meeting of the Ohio Academy of Science, Columbus, Ohio, on April 24, 1953. Publication authorized by the Director, U. S. Geological Survey.

THE OHIO JOURNAL OF SCIENCE 55(1): 13, January, 1955.

by till layers resulting from repeated glaciation can be recognized in many areas in Ohio. The permeabilities of these separated deposits differ in many cases. The results of aquifer-hydraulics tests at several sites provide a means for detecting changes in the permeability of an aquifer, from which knowledge of the subsurface geology of an area may be gained and the geologic history inferred.

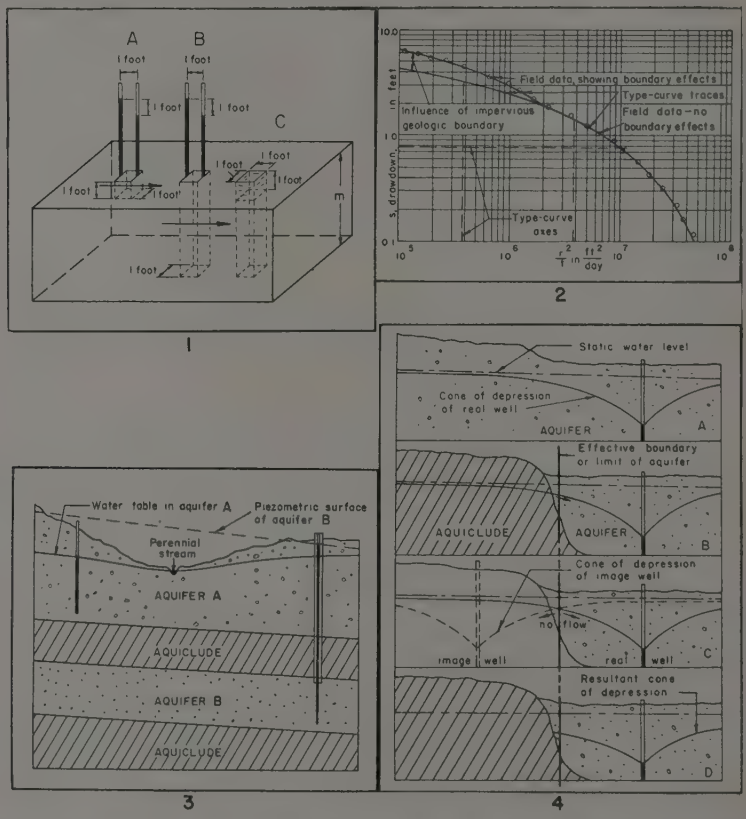


FIGURE 1. Diagrammatic representation of the coefficients of permeability (A), transmissibility (B), and storage (C).
FIGURE 2. Diagrammatic representation of water-table and artesian conditions.
FIGURE 3. Log graph of aquifer-hydraulics test data.
FIGURE 4. Diagrammatic representation of the image-well theory.

The field coefficient of permeability, P, is defined as the rate of flow of water in gallons per day through a cross-sectional area of 1 sq. ft. of the aquifer under a hydraulic gradient of one foot per foot at the prevailing temperature of the ground water. (The laboratory coefficient is the same except that it is corrected to 60° F. so that samples from different areas can be compared directly). Although a hydraulic gradient of 1 foot per foot is used for convenience in the definition, it is not representative of field conditions. Instead, the gradient is usually expressed

in feet per mile for flow through a section 1 ft. thick and 1 mile wide. The coefficient of permeability is represented by diagram A on figure 1. In natural materials it may range from a small fraction of a gallon per day per square foot to several thousand gallons per day per square foot.

THE COEFFICIENT OF TRANSMISSIBILITY

The coefficient of transmissibility, T, is defined as the rate of flow of water in gallons per day through a vertical strip of the aquifer 1 foot wide and extending the full saturated thickness under a hydraulic gradient of 100 percent (1 foot per foot) and at the prevailing temperature of the water. The coefficient of transmissibility is represented by diagram B on figure 1. In aquifers capable of yielding usable supplies of water to wells, it may range from a hundred or a few hundred gallons per day per foot to several million gallons per day per foot.

$P=\frac{T}{m}$ or $T=Pm$, where P is the field coefficient of permeability, T is the coefficient of transmissibility, and m is the saturated thickness of the aquifer.

THE COEFFICIENT OF STORAGE

Water must be supplied from storage in the aquifer until the required hydraulic gradient from the recharge area is established, or natural discharge is salvaged at the point of withdrawal. Under artesian conditions water is derived from storage by the compaction of the aquifer and its associated beds, and by expansion of the water itself. Under water-table conditions ground water is derived from storage mainly by the dewatering of a portion of the aquifer, but the coefficient of storage (see below) includes not only the water drained by gravity from the dewatered volume, but also a small amount of water derived from the underlying, still saturated, zone as described for artesian conditions. Thus the amount of water yielded from storage under water-table conditions is generally many times larger than that yielded under artesian conditions. Artesian and water-table conditions are shown on figure 2.

The storage properties of an aquifer are expressed by its coefficient of storage, which is defined as the quantity of water, expressed as a fraction of a cubic foot, that is discharged from each vertical prism of the aquifer with a base area of 1 sq. ft. and height equal to that of the aquifer, when the water level falls 1 foot. The coefficient of storage, S, under water-table conditions is represented by diagram C on figure 1.

THE CONE OF DEPRESSION

Ground-water reservoirs under natural conditions attain a state of approximate equilibrium in which discharge balances recharge. Artificial extraction of water from the reservoir, such as pumping from a well, disturbs the natural state of equilibrium. As pumping continues, a cone of depression with its center at the pumped well spreads out from the well in all directions until either (1) a hydraulic gradient is established from the recharge area of the aquifer to the pumped well sufficient to bring from the recharge area the amount of water being pumped, or (2) sufficient water is diverted from an area of natural discharge to balance the pumpage. The dimensions of the cone of depression depend upon the rate of recharge, the water-bearing properties and extent of the aquifer, and the rate and duration of pumping.

THE NONEQUILIBRIUM FORMULA

The formula used most widely to determine the coefficients of transmissibility and storage of an aquifer is the nonequilibrium formula (Theis, 1935). The nonequilibrium formula was derived by analogy between the flow of ground water and the flow of heat by conduction. Later Jacob (1940) derived this formula

using hydraulic principles only. Well-hydraulics formulas developed prior to the nonequilibrium formula were based on the assumption that pumping had continued long enough to establish steady-state conditions. The Theis non-equilibrium formula first introduced the time factor and the coefficient of storage.

The nonequilibrium formula is

$$s = \frac{114.6\ Q}{T} \int_{u}^{\infty} \frac{e^{-u}}{u} du \qquad (1)$$

where $u = \frac{1.87\ r^2 S}{T\ t}$ (2)

s = drawdown in feet at observation well
Q = discharge of pumped well in gallons per minute
r = distance in feet from pumped well to observation well
t = time in days since pumping began
T = coefficient of transmissibility in gallons per day per foot
S = coefficient of storage

The formula was developed on the basis of the following assumptions: that the aquifer is infinite in areal extent and is of the same thickness throughout, that it is homogeneous and isotropic (that is, its transmissibility is constant at all places and in all directions), that it is confined between impermeable beds, that the discharge of the pumped well is constant, that the coefficient of storage is constant, and that water is released from storage instantaneously with a decline in artesian head.

The value of the exponential integral $\int_{u}^{\infty} \frac{e^{-u}}{u} du$ is written symbolically as W(u) and can be computed by the following series:

$$W(u) = -0.577216 - \log_e u + u - \frac{u^2}{2.2!} + \frac{u^3}{3.3!} - \frac{u^4}{4.4!} \ldots\ldots\ldots \text{etc.}$$

The nonequilibrium formula may be written as

$$s = \frac{114.6\ Q\ W(u)}{T} \qquad (3)$$

W(u) is read "well function of u." Values of W(u) for values of u from 10^{-15} to 9.9 were published in a report by Wenzel (1942).

The presence of two unknowns and the nature of the exponential integral make an exact analytical solution impossible. T occurs twice in the equation and a solution by trial would be most laborious.

Theis devised a graphical method which makes solution of the equation relatively simple. Equations 2 and 3 are rewritten:

$$u = \left[\frac{1.87\ S}{T}\right] \frac{r^2}{t} \qquad (4)$$

and $$W(u) = \left[\frac{T}{114.6\ Q}\right] s \qquad (5)$$

The terms within the brackets are constant for a given aquifer and pumping rate. Equations 4 and 5 are similar and s is related to $\frac{r^2}{t}$ in the same manner that W(u) is related to u. If values of W(u) are plotted against corresponding values of u, and values of s are plotted against values of $\frac{r^2}{t}$, on cross-section arithmetic paper, the two curves will be similar but not identical in shape and curvature because the variables in the right halves of equations 4 and 5 are multiplied by different constants. Equations 4 and 5 may be rewritten:

$$\log u = \log \left[\frac{1.87\ S}{T} \right] + \log \frac{r^2}{t} \qquad (6)$$

and

$$\log W(u) = \log \left[\frac{T}{114.6\ Q} \right] + \log s \qquad (7)$$

In logarithmic form, multiplication becomes addition. A "type curve," representing the value of the exponential integral, is constructed by plotting values of W(u) against u on logarithmic paper. Values of s plotted on logarithmic paper against values of $\frac{r^2}{t}$ describes a "field-data curve" that is similar to the type curve. The difference in the constant multipliers of equations 4 and 5 cause relative displacement in the horizontal and vertical scales of the type curve and field-data curve plots. The field-data curve is superposed over the type curve. The coordinate axes of the two curves are held parallel and a match of the field-data curve to the type curve is obtained. In the matched position the vertical scales of the graphs are displaced with respect to one another by amount $\log \left[\frac{T}{114.6\ Q} \right]$ and the horizontal scales are displaced by the amount $\log \left[\frac{1.87\ S}{T} \right]$. A point on the type curve is selected and marked on the field-data curve. The coordinates of this common point, s, u, W(u), and $\frac{r^2}{t}$ are used in the nonequilibrium formula to determine the coefficients of transmissibility and storage. T is calculated using equation 3 with the W(u) and s coordinates. S is calculated using equation 2, the calculated value of T, and the $\frac{r^2}{t}$ and u coordinates of the match point. Figure 3 is a log graph of aquifer-hydraulics test data with a type curve superposed.

Details and variations of the methods available for determining the permeability of an aquifer are illustrated in the literature cited.

HYDROGEOLOGIC BOUNDARIES

The nonequilibrium formula was developed on the assumption that the aquifer being tested is infinite in areal extent. This condition of course is not satisfied in nature, although in large aquifers it may be satisfied for all practical purposes. Geologic conditions and surface hydrologic features limit most ground-water reservoirs to such an extent that their influence must be taken into account, at

least in making long-term predictions of the effect of pumping. Hydrogeologic boundaries (Ferris, 1951), may consist of folds, faults, or impervious layers of shale or clay, or major changes in permeability caused by an increase or decrease in the number or size of pores or fractures, or the amount of included material of low permeability such as clay. Streams also form boundaries.

THE IMAGE WELL THEORY

The nonequilibrium formula may be used for the finite aquifer, if adjustment for the effect of hydrogeologic boundaries is made by means of the image-well theory. The hydrogeologic boundaries may be located from aquifer-hydraulics test data by utilizing the nonequilibrium formula and the law of times (described later in this report).

Most hydrogeologic boundaries are not clear-cut straight-line features but are irregular in shape and extent. However, because the area of the test site is relatively small compared to the areal extent of most aquifers, it is generally permissible to treat hydrogeologic boundaries as straight-line demarcations. Where this can be done, boundary problems can be solved by the substitution of a hypothetical hydraulic system that satisfies the hydrogeologic limits of the real system.

The method of images was devised by Lord Kelvin. The method of images as applied to ground-water hydrology may be stated as follows: The effect of an impervious geologic boundary (barrier) on the drawdown in a well as a result of pumping from another well is the same as though the aquifer were infinite and a like discharging well were located across the real boundary on a perpendicular thereto and at the same distance from the boundary as the real pumping well. For a boundary formed by a stream connected with the aquifer (line source) the principle is the same except that the image well is assumed to be recharging the aquifer instead of pumping from it.

For a demonstration of the image-well theory, consider an aquifer bounded on one side by an impervious formation. The impervious formation cannot contribute water to the pumped well. Water cannot flow across a line that defines the effective limit of the aquifer. The problem is to create a hypothetical infinite hydraulic system that will satisfy the boundary conditions dictated by the finite aquifer system.

Consider the cone of depression that would exist if the geologic boundary were not present, as shown by diagram A on figure 4. If a boundary is placed across the cone of depression, as shown by diagram B, the hydraulic gradient cannot remain as it was because it would cause flow across the boundary which is impossible. An imaginary discharging well placed across the boundary perpendicular to and equidistant from the boundary will produce a hydraulic gradient from the boundary to the image well equal to the hydraulic gradient from the boundary to the pumped well. A ground-water divide would exist at the boundary, as shown by diagram C, and this would be true everywhere along the boundary. The condition of no flow across the boundary line now has been fulfilled. Therefore, the imaginary hydraulic system of a well and its image counterpart in an infinite aquifer satisfies the boundary conditions dictated by the field geology of this problem. The resultant real cone of depression is the summation of the components of both the real and image well depression cones as shown by diagram D on figure 4.

When pumping begins, the water level in an observation well will draw down at an initial rate under the influence of the pumped well only. When the cone of depression of the image well reaches the observation well, the rate of drawdown will change. It will be increased in this instance because the total rate of withdrawal from the aquifer is now equal to that of the pumped well plus that of the

discharging image well. Thus, the drawdown curve of the observation well is deflected downward.

If an aquifer-hydraulics test is conducted without prior knowledge of the existence of the impervious geologic boundary, it may be possible to locate the boundary by determining the position of the image well. The image well can be located by using data on the deflection of the drawdown curve under the influence of the discharging image well.

THE LAW OF TIMES

The law of times defined by Ingersoll, Zoebel, and Ingersoll (1948, p. 89) is

$$t_1/r_1^2 = t_2/r_2^2 = t_3/r_3^2 = \ldots\ldots\ldots t_n/r_n^2 \quad (8)$$

The law of times as applied to ground-water hydrology may be stated as follows: For a given aquifer the times of occurrence of equal drawdown vary directly as the squares of the distances from an observation well to pumping wells of equal discharge. It follows, that, if the time intercept of a given drawdown in an observation well caused by pumping a well at a known distance is known, and if the time intercept of an equal amount of divergence of the drawdown curve caused by the effect of the image well is also known, it is possible to determine the distance from the observation well to the image well using this law of times.

Values of s and $\frac{r^2}{t}$ are plotted on log paper and the type curve is matched to the portion of the field-data curve that represents the effect of the real well only. The coefficients of transmissibility and storage are computed using these match-point coordinates and equations 2 and 3. The type curve is again matched to the field curve, this time over that portion of the drawdown curve influenced by the image well. A convenient intercept, r_p^2/t_i, is selected and the divergence of the two type-curve traces is noted. The intercept, r_p^2/t_p, of an equal drawdown on the earlier portion of the field-data curve is determined. The distance from the observation well to the image well is calculated using the following formula which expresses the law of times.

$$r_i = r_p \sqrt{\frac{r_p^2}{t_p} \Big/ \frac{r_p^2}{t_i}} \quad (9)$$

r_i = distance in feet from observation well to image well

r_p = distance in feet from observation well to pumped well

t_p = time in days since pumping began for a particular value of s to be observed, before the boundary becomes effective

t_i = time in days since pumping began when the divergence of the drawdown curve from the type curve, under the influence of the image well, is equal to the value of s at t_p

Figure 3 is a log graph of aquifer-hydraulics test data showing the influence of an impervious geologic boundary.

If the distance to the image well from at least three observation wells can be calculated, the position of the boundary can be determined. The distances are scribed as arcs using the respective observation wells as centers; the intersection of these arcs locates the image well. The boundary is oriented perpendicular to, and crosses the midpoint of, a line joining the pumped well and the image well.

Aquifers limited in areal extent by two geologic boundaries can be analyzed by methods similar to those pertaining to a single boundary problem. Line-source boundaries formed by streams can also be located and analyzed from aquifer-hydraulics test data. These two problems, however, are beyond the scope of this paper.

The boundaries determined from aquifer-hydraulics test data represent the limits of a hypothetical aquifer system that is equivalent hydraulically to the real

system. Although these effective boundaries do not completely describe the actual geologic boundaries of the aquifer, they do determine the location of the idealized geologic boundaries within reasonable limits. Aquifer-hydraulics tests, therefore, serve as aids to geophysical exploration and can greatly reduce the number of test wells required to confirm the existence of a geologic boundary (Ferris, 1951).

The collection of aquifer-hydraulics test data forms a part of water-resources investigations by the Ground Water Branch of the U. S. Geological Survey and its many cooperating State agencies. Several such tests are made each year in Ohio by the U. S. Geological Survey in cooperation with the Ohio Division of Water. Within a few years enough data will have been collected and analyzed to aid greatly in the interpretation of the geology of Ohio as it relates to the quantitative appraisal of the States' water resources.

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Fresh-water Invertebrates of the United States. *Robert W. Pennak.* The Ronald Press Co., New York. 1953. ix + 769 pp. 470 figs. $14.00.

For a long time there has been a need for an up-to-date treatise on the free-living fresh-water invertebrates of the country. Zoologists are indebted to Dr. Pennak for assuming the task and filling the need. This book, eleven years in preparation, is the only modern, comprehensive work in its field. The author has sifted, selected, and organized the pertinent information on the general biology and classification of the invertebrates. An introductory chapter sets the stage with a brief discussion on the origin of the fresh-water fauna, comparisons between marine and fresh-water invertebrates, and several ecological topics of general interest. Thirty-six chapters are devoted to the major groups of fresh-water invertebrates including the insects. These chapters were examined critically by 40 specialists, some of whom contributed much in the construction of the keys. Each chapter is organized in the following sequence: general characteristics; locomotion; feeding and digestion; circulation; respiration; excretion; muscle system; nervous system and behavior; reproduction and development; ecology and geographical distribution; enemies and parasites; economic importance; collecting, preserving, and culturing; and taxonomy. Occasional special topics such as color, encystment, periodicity, etc., are included where they are of particular value.

The illustrations, mostly adapted and modified from published sources, were nevertheless made especially for this book by the author. They are large, clear, well made, and especially selected and drawn to illustrate the key characters. References are made in the keys to all points which are illustrated. There is an appendix of two sections on (1) field and laboratory apparatus and (2) reagents and solutions. The index is complete to taxa, but not to terminology.

This text was written for advanced undergraduate and graduate students and for professional zoologists, limnologists, fishery biologists, and aquatic entomologists. Emphasis has been given to taxonomy, natural history, and geographical distribution. Needs and suggestions for future research are frequently given. The type is large and clear; the paper and binding are of excellent quality. Very few typographical errors have been found by this reviewer and the only universal criticism received from his students is the absence of a glossary. This book will be invaluable to all concerned with free-living fresh-water invertebrates, and undoubtedly will stimulate further research on the part of younger students to fill in some of the gaps in our knowledge of the fresh-water fauna, a function which Dr. Pennak had set as one of his goals in preparing this volume.

RALPH W. DEXTER

A PRELIMINARY NOTE ON EGG PRODUCTION FROM MILK-FED MOSQUITOES[1]

A. O. LEA, J. A. KNIERIM, J. B. DIMOND AND D. M. DELONG
Department of Zoology and Entomology, The Ohio State University, Columbus 10

The usual procedure in rearing mosquitoes is to supply the adults with a blood meal from a living host in order to obtain viable eggs. It has been customary for several years to maintain cultures of *Anopheles quadrimaculatus* and *Aedes aegypti* in the research laboratories of the Department of Zoology and Entomology of The Ohio State University, by feeding the adult mosquitoes on rabbits. However, the expense and time required in raising and handling the rabbits was so great that investigations were initiated to find a substitute for living hosts.

Preliminary studies showed that citrated beef blood could be used satisfactorily for both species if offered under certain conditions.

As a food source for males and supplementary food for females, both the stock and test cages of the mosquitoes were always provided with a solution of 9 parts water and 1 part honey absorbed on a cotton pad. It seemed possible that the female mosquitoes might take blood from the pad if offered as a 9 part blood and 1 part honey mixture.

The *Aedes* females fed on the blood-honey mixture at room temperature and laid viable eggs. For 9 months the stock colony had no living host on which to feed; instead, a blood-honey pad was the only food source during this period. Best results were obtained if the blood-honey pad was placed on the top of the screened stock cage or suspended in the middle of the cage rather than placed on the bottom of the cage in a Petri dish. Egg production by this method appeared to be equal to that from a living host, and was certainly far more abundant than that needed for testing purposes.

McLintock (1952) had also used this technique to feed adults 1 part of 10 percent sucrose solution to 3 parts of difibrinated pig, beef, or sheep blood.

Results with *Anopheles* mosquitoes using the above method were poor, however, observations in this laboratory had indicated that temperatures higher than room temperature played a greater role in host attraction with *A. quadrimaculatus* than with *A. aegypti*. Subsequent experiments showed that the Anophelines would flock to and engorge on citrated beef blood absorbed on cotton (no honey), if the blood temperature was maintained between about 93°–95° F. Initial tests were run by wrapping blood-soaked cotton around a test tube and placing hot water into the tube to get the desired temperature for feeding. For use in the stock cage, a U-tube was fitted into one side of the cage while the two ends were exposed to the outside. The tube was wrapped with blood-soaked cotton, and water at 115°–120° F flowed through the tube to maintain the desired range of temperature. Under these conditions, the temperature recorded with a thermocouple at the surface of the cotton was maintained at 93°–95° F. Generally, most of the mosquitoes engorged within the first 30 minutes.

After establishing the fact that the cultures could be maintained using extracted beef blood rather than a live animal, studies were made to determine whether eggs could be obtained using a more readily available material than preserved blood. Fielding (1919), feeding *A. aegypti* a peptone-sugar water solution, succeeded in obtaining a few fertile eggs. However, Young (1922) and Gordon (1922), could not repeat these results.

[1]This work has been aided by a research grant from the Department of Health, Education, and Welfare of the National Institutes of Health through The Ohio State University Research Foundation, Columbus, Ohio.

In the present study, it was found with both of these mosquitoes, skimmed milk could be substituted for blood as an egg producing agent. *A. quadrimaculatus* also laid viable eggs when fed a mixture of proteose-peptone, liver concentrate, and casein hydrolysate. Feeding methods for each species were the same as outlined above.

Mosquito larvae are useful insects in certain bioassay tests. If large numbers of eggs can be produced by maintaining a stock colony on a material as cheap and available as milk, this work will be greatly facilitated.

These results are certainly ample evidence that blood itself is not a prerequisite for egg production in mosquitoes. It has been suggested by various investigators that one or more proteinaceous materials are essential, and it may be possible that these substances can be fully determined.

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Record of the Rocks. *H. G. Richards.* The Ronald Press Company, New York. 1953. xiii + 413 pp. $6.00.

The regional emphasis of this book is for the benefit of students of "general geology, . . . and local and field geology". The extensive treatment of the post-Paleozoic rocks of the Coastal Plain is intended to augment the reference value of the book. It is really a textbook of historical geology, of the orthodox form, with an unusually extended introductory section on rocks, time, stratigraphic interpretation, movements of land and sea, etc. This section is generally good, and especially so in the recognition of the arbitrary nature of period and era boundaries. The stratigraphic taxonomy shows little similarity to current practice, however "System" is used for both whole periods and parts of periods, and "series" is a unit intermediate between formation and group. The section on plant and animal classification includes too many names for the beginner and not enough descriptive detail for the advanced student: e.g., Conularida are listed, not illustrated, and described only as possessing "a thin shell and transverse septae". The digrammatic treatment of the hypotheses of earth origin is unusually good, but 1953 is too late a date to skimp on the exposition of the post—1940 hypotheses. The chapters on the several periods emphasize the aspect of a stratigraphic catalog, and include abundant formation and fossil names. This serves the reference purpose of the book, but provides only a slough of despair for the common student in a course in historical geology. Captions for the numerous fossil plates mix binomials, suprageneric names, and anglicized equivalents. The book contains a wealth of expository material on the eastern United States, but much of it in rather an outline form. In fact, the book reads rather like the lecture notes taken by a student; the suggestive key words and phrases are there, but by themselves they do not constitute descriptive text, and, filled out, they would represent professional specialization in the geology of the eastern United States. As a reference work for the professional this book is probably insufficiently specific. As a reference work for the amateur it is probably excellent. As a textbook administered whole it is likely to suffocate the student, and, if used only as a source to supplement lectures in historical geology, it is too provincial.

MALCOLM P. WEISS.

SPONTANEOUS GOITER AND CANCER OF THE THYROID IN ANIMALS[1]

HANS G. SCHLUMBERGER, M. D.

Department of Pathology, College of Medicine, The Ohio State University, Columbus 10

The role of trace elements in animal and plant nutrition is now under extensive investigation; however, it was over a century ago that Chatin (1850) presented evidence that the absence of iodine in the diet leads to goiter and cretinism. This foreshadowed many studies on the geographical distribution of iodine in foods, water, and soil, the results of which permitted McClendon (1939) to write, ". . . it seems possible that goiter maps and iodine maps, supposing they existed, would fit like the land fits the ocean, goiter incidence and iodine varying inversely."

These studies have been largely limited to the occurrence of goiter in man and a few domestic animals. The systematic investigation of feral animals living in so-called goiter areas has not been undertaken, and only a few reports of goiter and thyroid cancer in captive wild animals are available. It would seem that research on adaptive hyperplasia of the thyroid in response to insufficient iodine in the diet of native animals should be a cooperative effort of ecologists and pathologists.

FISHES

Among the cold-blooded vertebrates by far the most numerous studies of thyroid hyperplasia have been reported in fishes. Perhaps the first to call attention to goiter in fishes was Bonnet (1883), who described an epidemic of goiter that destroyed over 3,000 young lake trout, *Salmo lacustris*, in a German fish hatchery between February and June of 1883. The early literature has been reviewed elsewhere (Schlumberger and Lucké, 1948).

One of the most important studies of thyroid hyperplasia was reported in a series of papers by Marine and Lenhart detailing their observations on goiter among brook trout in a large Pennsylvania hatchery (1910 a, b; 1911). The development of the lesion was summarized by Marine (1914): "It was found that the thyroid hyperplasia began in the fry as soon as feeding was instituted, and advanced overgrowth was present at the fourth month of extra oval life; that the overgrowth progressively increased to the stage of clinical detectability, as ascertained by the reddening of the pharyngeal floor over the thyroid area about the tenth month in this hatchery; that visible goiters usually manifested themselves about the beginning of the second year . . . and progressively increased during the second and third years; that older fish were more resistant and tended toward spontaneous recovery." Iodine prevented the hyperplasia; in goiterous fish administration of iodine or removal from the hatchery ponds to an open brook effected a cure (1910b).

At a Wisconsin fish hatchery Hamre and Nichols (1926) observed the occurrence of unilateral or bilateral exophthalmos in trout-fry after resorption of the yolk sac. The thyroid was hyperplastic, the follicles were lined by columnar epithelium, and the lumina were devoid of stainable colloid. When 25,000 newly hatched fry were placed in water containing 100 parts of sodium iodide in a billion parts of water for 10 days, and were then kept in water containing 30 parts of sodium iodide per billion of water, exophthalmos and thyroid hyperplasia did not appear.

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[1]Read at the Brookhaven Symposium on the Thyroid, June 11, 1954, and published in "Brookhaven Symposia in Biology, Number 7".

Portions of this investigation were supported by research grants from the American Cancer Society and the National Cancer Institute, U.S.P.H.S.

The prevalence of goiter in trout and other *Salmonidae* may be due to their high oxygen requirement which is not met by the low oxygen tension of the water in hatchery tanks. Duerst (1941) stated that inactive fish such as carp require only 3–4 cc. of oxygen per liter of water, whereas trout need 7–8 cc. He believes that the functional demand upon the thyroid is in inverse proportion to the oxygen tension of the surrounding water. When the oxygen content of the water falls below 4 cc. per liter the young trout develop thyroid hyperplasia, at 1.5 cc. per liter they die of asphyxia; carp survive when there is only 0.5 cc. of oxygen per liter.

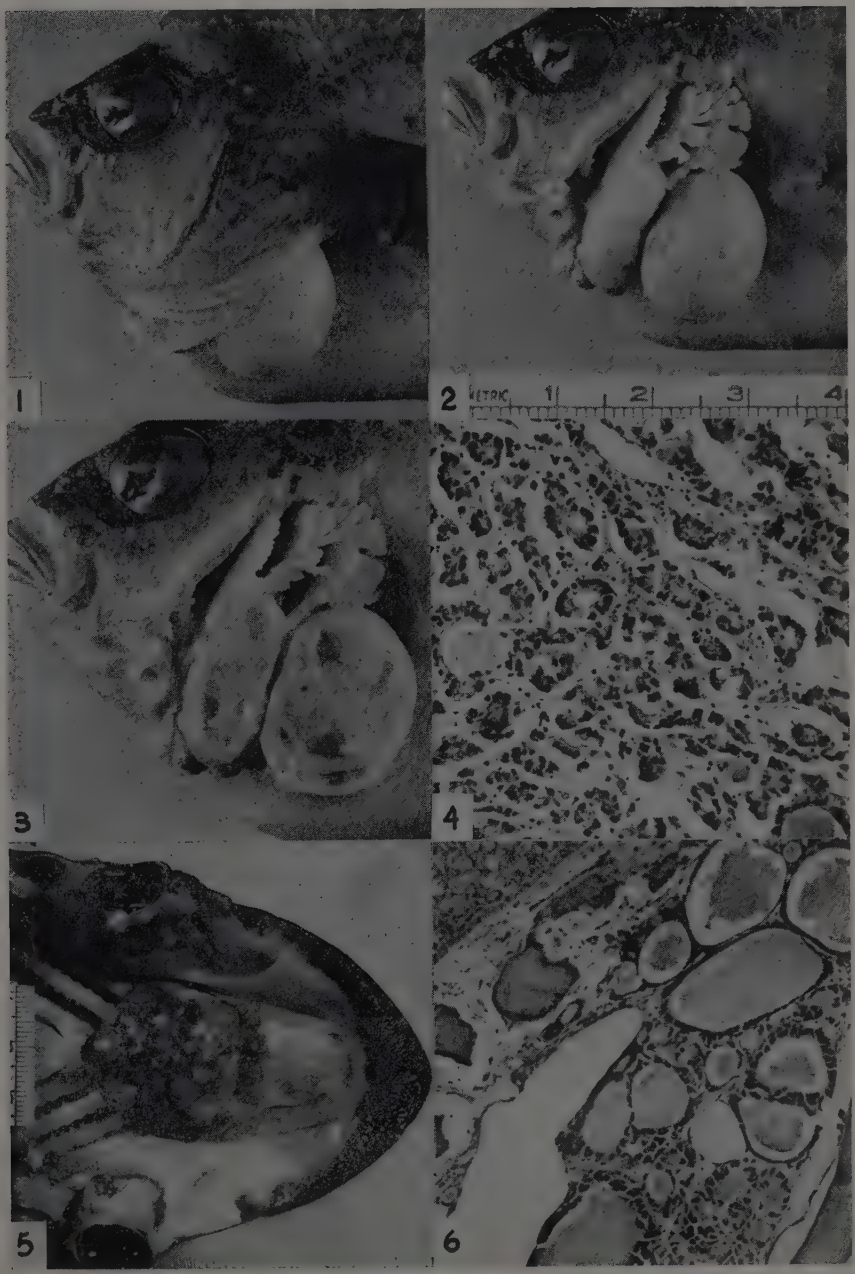
Isolated instances of goiter in other species of fresh water fishes have been reported (Schlumberger and Lucké, 1948). In the Scioto River of Ohio, with an iodine content of 0.21 μg. per kg. of water as compared with 0.83 μg. per kg. in the Mississippi River (McClendon, 1939), we have found several specimens of the long-eared sunfish, *Lepomis megalotis megalotis*, with goiter. In advanced cases the hyperplastic thryoid appears as a smooth spherical mass, often bilateral, that elevates the operculum and protrudes beyond its posterior margin (fig. 1 and 2). The cut surface may show the presence of cysts (fig. 3) similar to those occasionally found in human goiters. In histological sections colloid is seen in only a few large follicles; most of the follicles are small, have a lumen devoid of colloid, and are lined by tall columnar epithelial cells (fig. 4).

The occurrence of goiter in small tropical aquarium fishes has been reported several times (Schreitmüller, 1924; Müller, 1926; Smith, et al., 1936; Smith and Coates, 1937). Recent work by a group of investigators using a popular aquarium fish known as the "swordtail" is of particular interest. Gorbman and Gordon (1951) observed the occurrence of thyroid hyperplasia and neoplasia in an inbred stock of the swordtail *Xiphophorus montezumae*. The changes in the thyroid took place even though dried ocean shrimp with a high concentration of iodine made up a large part of the diet. Hyperplasia of the thyroid was not observed in the wild fish taken from their natural habitat in Mexico. A subsequent report by Berg, et al., (1953) indicated that when young fish were raised in iodized water, or adults with goiters were treated with potassium iodide, the treatment prevented the development of goiter in the former and occasioned regression in the latter. It was also discovered that highly inbred strains were more susceptible to the development of thyroid tumors and that these appeared at a much earlier age, suggesting a genetic factor leading to an exceptionally high iodine requirement of the fish. Using injections of a tracer dose of carrier-free I^{131} Berg and Gorbman (1954) showed that the thyroid tumors accumulated up to 60 percent of the injected isotope; uptake was rapid but turnover was slow. The radioautographs located most of the radioiodine in the apparently normal colloid-containing peripheral follicles and indicated the virtual absence of organic I^{131} in the more anaplastic parts of the growths.

The few reported cases of goiter in marine fishes have nearly all occurred in fish that were kept in aquaria for long periods (Cameron and Vincent, 1915;

EXPLANATION OF FIGURES IN PLATE I

1. Goiter in a long-eared sunfish, *Lepomis megalotis megalotis*, raising the operculum and protruding beyond its margin.
2. Same fish after removal of operculum showing compression and distortion of gills by the goiter.
3. Cut surface of goiter; a small hemorrhage and several cysts are seen.
4. Histologic appearance of goiter; large follicles with poorly stained colloid and small follicles devoid of colloid and lined by columnar epithelium. Mag. X 140.
5. Floor of mouth of pilot fish, *Echeneis naucrates*, showing a large goiter in the midline partly covering the anterior branchial arches.
6. Section of an arch showing surface epithelium and bone in approximation to "invading" thyroid tissue. Mag. X 100.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Marsh and Vonwiller, 1916; Nigrelli, 1952). Several years ago, in collaboration with Dr. Balduin Lucké (1948) the writer observed the occurrence of goiter in three pilot fish, *Echeneis naucrates*, exhibited at the Fairmont Park Aquarium in Philadelphia. Although fed on an iodine rich diet of fresh shrimp, oysters, clams, and chopped fish they all developed pink, translucent, coarsely lobulated tumors on the floor of the mouth (fig. 5). Microscopically the tumors proved to be thyroid, consisting in part of greatly dilated acini filled with marginally vacuolated colloid and lined by cuboidal or columnar epithelium. Alternating with the large colloid spaces were areas in which the acini were small; occasionally thyroid tissue was found between lamellae of bone (fig. 6). About a year later 13 pilot fish were received from another aquarium, none had gross evidence of goiter; however, within a year goiters 1–3 cm. in diameter were seen in all of them. On revisiting the aquarium 6 years later only a single survivor remained; it displayed a prominent 4 cm. goiter on the floor of the mouth. Analysis of the water in the tank showed an iodine content of only 7.8 μg. per kg., as compared with 37 μg. per kg. in ocean water collected on the following day.

Despite the low iodine content of the salt water in the Philadelphia aquarium no other species of marine fishes kept there showed gross evidence of goiter over a period of 12 years. It appears probable that the metabolic need for iodine is greater in this species than in others. A similar suggestion has been made by Berg, et al., (1953) in their study of the fresh water swordtail *X. montezumae*. This fish is only one of 7 species of Xiphophorin fishes that have been maintained by inbreeding for many generations under practically identical environmental conditions. In only 2 species, *X. montezumae* and *X. pygmaeus*, have the majority of a brood developed hyperplastic or neoplastic thyroids.

To distinguish between a hyperplastic or nodular goiter and a benign tumor is as difficult in fishes as it is in man. Furthermore, in fishes even the recognition of malignancy in the thyroid offers a serious problem. Many early investigators identified goiter in fishes as carcinoma because they interpreted the presence of thyroid follicles among adjacent muscle bundles and bone lamellae as evidence of invasion. However, as early as 1911 Gudernatsch had shown that the teleost thyroid is not encapsulated and that its follicles do not form a distinct organ but are scattered over a wide area. The following year Gaylord and Marsh (1912) published a much quoted monograph entitled "Carcinoma of the Thyroid in the Salmonoid Fishes," based on thyroid enlargements seen in several thousand trout at government fish hatcheries. Study of the histological descriptions and photomicrographs, however, suggests that most cases were examples of hyperplasia and colloid storage without evidence of malignant change. It cannot be denied that among these many thousand goiters there probably were instances of adenocarcinoma. In 2 cases metastases were recognized; one presented as a small mass in the wall of the rectum; the other, less clearly a metastasis, was a nodule on the tip of the mandible. Recently Baker, et al., (1954) reported extensive invasion of the head, pericardium, and myocardium of *Xiphophorus maculatus* by thyroid cells. Masses of unencapsulated cystic follicles were also found in the kidneys. Radioactive iodine injected into tumor-bearing fish yielded definitive radioautographs from cross sections through the kidney and thyroid regions.

AMPHIBIANS

Despite extensive work on amphibian thyroid physiology, including study of its role in tadpole metamorphosis, no report of goiter could be found in the literature. However, Professor J. M. Dodd (1954) at the Gatty Marine Laboratory of the University of St. Andrews in Scotland will shortly publish an account of spontaneous goiter in newts. In a personal communication Professor Dodd wrote that he had collected 5 goiterous newts in a small pond quite near the sea at Crail in Fife two years ago. Since then no additional goiterous animals were found. In

most cases the goiters were well marked and in photographs of the specimens a distinct ventral swelling is visible in the midline at the junction of head and trunk. The urodele was identified as *Triturus helveticus* and in all cases the goiters were associated with neoteny. The year before the goiterous newts were found, a crop of yellow turnips was grown in the field bordering the pond. Professor Dodd suggests that a possible explanation for the appearance of goiters in the newts may be the introduction of thiocyanates (brassica factor) by contamination of the pond with feces of rabbits feeding on the turnip tops.

An interesting ecological study on the frog thyroid has been carried out by Adler (1916). This investigator found that the histological appearance of the thyroid of tadpoles and frogs of the same species, *Rana temporaria*, varied with the environmental habitat of the animal. The cold-adapted alpine animals had large thyroids with many small follicles. The warm-adapted larvae from the shores of the Adriatic were distinguished by their relatively small thyroids composed of a few large follicles. The possible effect of differences in iodine content of the water was not examined.

In an excellent review on the thyroid gland and its functions in cold-blooded vertebrates Lynn and Wachowski (1951) record no instance of spontaneous hyperplasia of the thyroid in an amphibian, although they refer to numerous reports on experimental hyperplasia produced with thyroid antagonists and inhibitors. The frogs and toads (Anura) have been more frequently employed in these studies than have the newts and salamanders (Urodeles) probably because of the interest centering about the effect of the induced thyroid changes on metamorphosis in the anura.

In a study on the effects of thiourea administration upon thyroid histology in the frog, Joel, D'Angelo, and Charipper (1949) pointed out that the response of the amphibian thyroid to goitrogens is less marked than that of higher vertebrates. The qualitative and quantitative changes produced by these drugs are less pronounced than those which occur in the chick or mammal after similar treatment.

REPTILES

In a cursory search of the literature only 3 reports of goiter in reptiles were found; of these animals, 2 were turtles and 1 a lizard. All had been on exhibition in zoological gardens for several years suggesting a probable dietary deficiency of iodine.

A Brazilian fresh water turtle, *Platemys geoffroyana*, died at the Berlin Aquarium in 1903. The neck organs were examined by Pick and Poll (1903) who described a $6\times4\times2.5$ cm. egg-shaped mass on the ventral aspect of the specimen. Histologically the tumor was composed of tubular acini lined by tall columnar epithelial cells and separated by moderate amounts of connective tissue stroma. The second turtle, *Testudo nigrita*, died at the London Zoological Gardens and was autopsied by Hamerton (1930) who found one of the two laterally placed thyroids enlarged to the size of a golf ball—about 2 times normal size. The 2 thymus glands of this animal were also enlarged, each attaining the size of a coconut!

Müller (1926) described a goiter he found in a large lizard, *Zonurus giganteus*, that had been on exhibition at the Zoo in Frankfurt, Germany. One of the thyroids was greatly enlarged and measured $3\times3.5\times1$ cm. It compressed the trachea and esophagus; breathing was impaired and death was due to starvation.

Whereas thyroid physiology in amphibians has been thoroughly investigated, in reptiles it has been neglected. Lynn and Wachowski (1951) suggest that one of the chief factors hampering the study of thyroid function in reptiles is their low survival rate after operation. However, studies with thyroid inhibiting drugs are being undertaken. Adams and Craig (1951) found that in a lizard, *Anolis carolinensis*, thiourea or thiouracil administration produced gross enlargement of the thyroids; and histological sections showed marked hypertrophy of the follicular

epithelium with almost total loss of colloid. Response of the adult painted turtle, *Chrysemys picta*, was less striking (Adams and Craig, 1950), although in some animals there was an increase in height of the follicular epithelium as well as liquefaction and loss of colloid. The thyroid of reptiles, like that of amphibians, appears to be less responsive to these inhibitors than is the thyroid of birds and mammals.

BIRDS

Among the cold-blooded vertebrates the effect of the thyroid hormone in controlling the rate of body metabolism appears to be very slight or absent (Lynn and Wachowski, 1951). In birds and mammals, however, this regulatory action is an important function of the hormone. The metabolic rates of these groups when compared among animals of the same weight show striking differences. Benedict (1938) found that at 37° C a 20 g. fish would produce about 30 calories per kg., a 20 g. mouse 150 calories per kg., and a 20 g. canary 250 calories per kg. Among larger animals comparable differences are observed. The much higher metabolism of birds than of their mammalian weight equivalent may be reflected in the greater size of the avian thyroid in proportion to body weight. Cruickshank (1930) has found 3 times as much iodine in the thyroid of birds as in that of mammals.

In fowl as in most birds the thyroids are discrete bilateral glands at the base of the neck. Their size is susceptible to considerable variation depending on the age and sex of the bird as well as on the season of the year (Cruickshank, 1930). The reported cases of goiter in chickens are nearly all from regions known to be poor in iodine; however, there is some difference of opinion regarding its frequency of occurrence. Schwarte (1952) has stated that goiter among domesticated birds in the goiter belt states of the Northwest and Great Lakes regions is rare. Even before the general use of iodized salt Kernkamp (1925) found only 2 cases of goiter, both fowl hens from the same farm, among autopsies of 2,221 chickens, 141 turkeys, 42 geese, and 15 ducks. In this same area swine and sheep were often affected with goiter. On the other hand, Kalkus (1920) observed goiter frequently among the chickens of Washington, and Welch (1928) stated that in Montana goiter in poultry is very common. However, the thyroids, which may each be as large as a thumb, are entirely concealed by feathers; no ill effects on the bird were noted. Fritschi (1926) reported 2 cases of goiter in chickens from a mountain canton in Switzerland and cited 7 additional instances of goiter in fowl described by Backlehner at Munich.

Riddle (1929) has carried out extensive investigations on the metabolism of doves and pigeons. During these studies he observed that the thyroids of the birds undergo considerable enlargement in the winter and reduction in the summer. Similar seasonal changes were found by Haecker (1926) in the thyroids of crows, *Corvus corone*, caught in the Swiss and Austrian alps. Riddle further noted that the thyroids of pigeons and doves aged 30 to 90 months are in general distinctly larger than those of younger birds. Among 24 inbred races of ring doves he found 4 races in which the thyroids were characteristically large and 4 in which they were small.

Recently Hollander and Riddle (1946) reported the occurrence of goiter among pigeons from 2 non-goiterous areas, viz., Long Island and South Carolina. The goiters appeared with greatly varying frequency among birds on a fairly constant regimen without supplemental iodine. The birds were usually plump or even obese; the skin about the eyes was puffy. The large feathers were elongated and narrow; the small ones resembled hairs more than feathers. Feather regrowth was defective and in general the birds presented the appearance of myxedema. Their young showed pronounced weakness at the time of hatching, an abnormality not seen in the offspring of female thyroidectomized pigeons. Small amounts of

iodine added to the diet prevented the appearance of goiter in the adults and weakness of the newly hatched birds.

The Australian shell parrakeet or budgerigar, *Melopsittacus undulatus*, is widely bred in this country as a cage bird or pet and may be classed with the domesticated birds. Large numbers of parrakeets received from many different states have been studied in this laboratory because of the high tumor incidence that characterizes this species. Among birds received during 1953, enlarged thyroids were found in 23. The normal thyroid of the parrakeet is a paired organ, one gland lying on either side of the trachea at the base of the neck. Each gland is oval, measures up to 2 mm. in greatest diameter, and 2-5 mg. in weight. Some of the thyroids were only 2 to 3 times normal size; others were up to 12 times the usual diameter and weighed over a gram (fig. 7A). Many of the largest glands

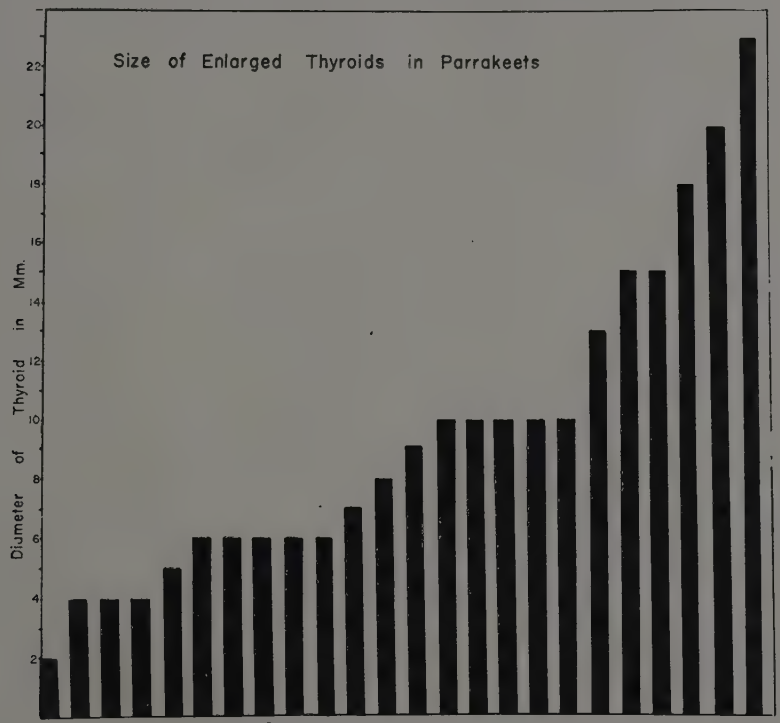

FIGURE 7A. The first bar represents the greatest diameter of the normal parrakeet thyroid gland. The remaining bars illustrate the different sizes reached by the enlarged glands.

were cystic and the cysts filled with a viscous amber fluid (fig. 7 to 9). Often one gland was much larger than the other, but even the smaller one was hyperplastic (fig. 8). Occasionally the goiters increased rapidly in size and were readily visible in the living bird. In such instances autopsy examination often showed that there had been extensive hemorrhage into the glands, greatly distending one or two large cysts. In one case the cyst had ruptured and the blood escaped into the body cavity.

Histologically the normal resting thyroid of the parrakeet has the usual follicular structure. The follicles are filled with well stained colloid devoid of vacuoles and

are lined by low cuboidal epithelium (fig. 10). In birds that are rearing young, the colloid stains less well and shows some peripheral vacuolization; the epithelium is taller. In the hyperplastic glands these changes are more pronounced; the lumina of the follicles are often small and irregular in shape, colloid is vacuolated and poorly stained or even absent. The epithelial cells are of increased height and frequently form papillary projections (fig. 11).

In two cases there was an associated pituitary adenoma; however, 92 parrakeets with pituitary tumors have been examined in this laboratory and no evidence of a distinct thyroid stimulating effect could be found (Schlumberger, 1954). Exophthalmos, which was first found only when the pituitary tumor had invaded the orbital space, has now been encountered several times when no such extension could be demonstrated. Whether the exopthalmos is a specific hormonal effect of the tumor is under investigation; however, in none of these birds was there evidence of thyroid hyperplasia.

TABLE 1

Geographic distribution of goiter in parrakeets

STATE	BIRDS WITH TUMOR+	BIRDS WITH GOITER	STATE	BIRDS WITH TUMOR+	BIRDS WITH GOITER
Massachusetts	4	0	Wisconsin	1	2
New York*	7	1	Minnesota	5	1
New Jersey	7	0	Nebraska	3	0
Florida	9	0	Arkansas	0	1
Kentucky	3	0	Texas	25	0
Pennsylvania**	15	1	Colorado	0	2
Ohio	31	8	Wyoming	1	0
Indiana	6	2	Washington	0	1
Illinois	7	4	California	7	0

*Rochester, N. Y. **Erie, Pa. Both cities are in low iodine areas.
+Other than thyroid tumors, to show relative number of birds received.

The stress of breeding and caring for the young appears to be a factor in the development of these goiters; 18 of the 23 cases were received during April to July which is a period of great activity in these birds. It does not, however, coincide with the period of thyroid enlargement noted by Riddle (1929) in pigeons and by Haecker (1926) in crows. The probability that gonadal-pituitary activity is related to the thyroid hyperplasia is also suggested by the sex ratio—21 of the 23 birds were females. This high incidence in the female, though perhaps not as striking, has also been found in chickens, pigeons, mammals, and even man (Crotti, 1938).

Although parrakeets are received from all parts of the country, those that had goiters came from areas known as the goiter belt (table 1). This is well illustrated

EXPLANATION OF FIGURES IN PLATE II

7. Large cystic thyroid extending into the body cavity of a male parrakeet, *Melopsittacus undulatus*.
8. Bilateral goiter in a female parrakeet. One of the enlarged thyroids lies just above the heart, on the left; a much larger goiter occupies the base of the neck, to the right of the trachea.
9. Cut surface of large goiter shown in preceding figure. Note colloid-filled cyst at superior pole.
10. Section of normal thyroid; follicles are filled with colloid and lined by flattened epithelium. Mag. X 85.
11. Section of goiter seen in Fig. 7. The follicles are irregular, colloid is vacuolated or absent— the epithelium is cuboidal or low columnar. Mag. X 135.

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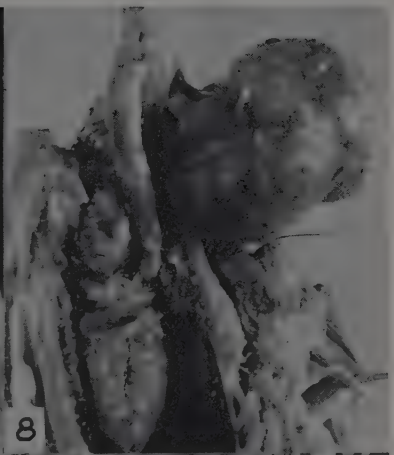
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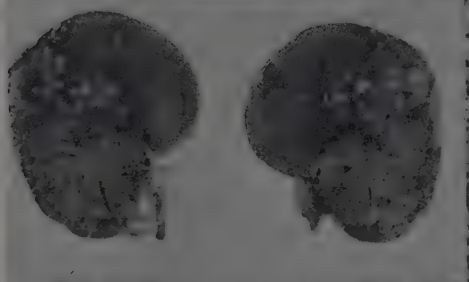
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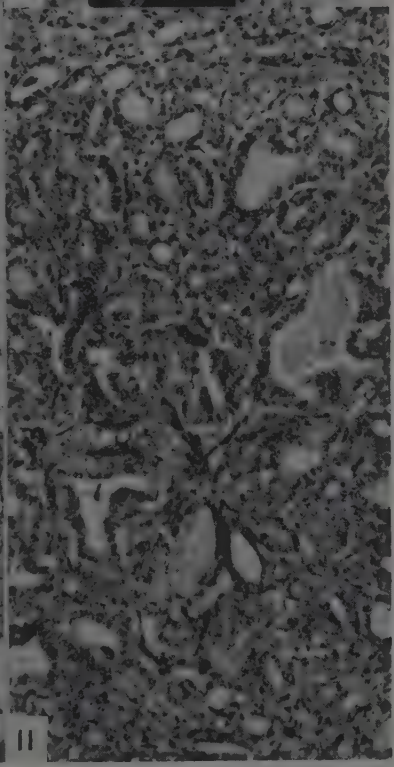
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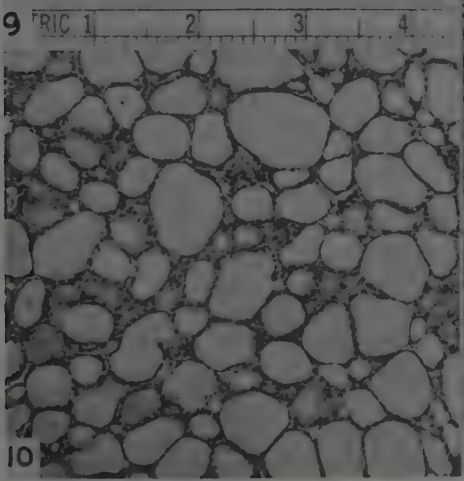
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by comparing two states from which a large number of birds was received. Among 39 birds from Ohio, 8 were goiterous; whereas of 25 parrakeets from Texas, none had enlarged thyroids. The diet of parrakeets is quite uniform throughout the country and consists chiefly of millet and canary seed with occasional addition of some oats and green foods. Rape seed, which is goiterogenic for chickens (Turner, 1946), is not used, nor is cabbage an item in the diet; carrot tops and spinach are the usual fresh foods offered. In the absence of a recognizable goiterogen in the food it seems probable that the geographical distribution of the goiterous birds is significant and may perhaps be linked with a low iodine content in the water. In some of these regions many breeders are aware of this and use a grit that has an iodine supplement.

No data is available on the occurrence of goiter among wild birds and only a few cases have been reported in captive birds. Those here described were autopsied at the London Zoological Gardens where most had been on exhibition for several years. A mandarin duck, *Axis galericulata*, had enlarged thyroids measuring an inch in diameter; death was attributed to pressure of the goiters on adjacent structures (Hamerton, 1933). An Eleanora's falcon, *Falcon eleanora*, died after 3 years in the Gardens. At autopsy an enormous cystic enlargement of the thyroids was found; each gland measured 8×15 cm. (Hamerton, 1935). The thyroids of a Houbara bustard, *Chlamydatis undulata*, were 2 cm. in diameter as compared with a normal of approximately 4 mm. In several areas the histological appearance resembled that of a papillary adenoma (Hamerton, 1936). A demoiselle crane, *Anthropoides virgo*, died from a hemorrhage into a large thyroid cyst that subsequently ruptured. The gland contained numerous other cysts and measured 2×0.5 cm. (Hamerton, 1937). A Chilean eagle, *Geranoaetus melanoleucus*, that had lived in the London Zoo for 27 years, was found to have enlarged thyroids, each measuring 5×3.3 cm. (Hamerton, 1942). In an Elliott's pheasant, *Calophasis elliott*, pressure was exerted on the major vessels of the neck by the enlarged thyroid glands and may have contributed to the death of the bird (Hamerton, 1943).

Cancer of the thyroid is rare in birds; Feldman and Olson (1952) do not list such a tumor in their recent extensive review on neoplasms of the chicken. Murray (1908) refers to a case of thyroid cancer in a macaw, *Ana macao*, and Fox (1923) describes a malignant tumor of the thyroid in a male shell parrakeet. The right thyroid was replaced by a 10×6×4 mm. mass; the left measured 5×3×2 mm. Each was well circumscribed, yellow-gray, and moderately firm. In histological sections thyroid tissue could be recognized at one edge; elsewhere the thyroid was replaced by poorly differentiated cells with scant cytoplasm and rather uniform spherical nuclei. Occasional cells were very large and had 2 or 3 nuclei. In a recent survey of neoplasms among captive wild birds at the Philadelphia Zoo, Ratcliffe (1954) found cancer of the thyroid in 2 psittacine birds and in one duck.

DOMESTIC MAMMALS

In regions where endemic goiter is common in man it is also prevalent among his domesticated animals. In the latter, however, it is chiefly significant as a disease of the newborn; when it appears in adult ruminants, swine, and horses the general health of the animal does not seem impaired (Madsen, 1942). Although both adult and congenital goiter occurs in the states bordering the Great Lakes (Andrews, et al., 1948), it is in the Northwest that the disease is of greatest economic importance. Before the introduction of iodized salt in the diet the mortality among newborn sheep, swine, and goats in Montana (Welch, 1928) and Washington (Kalkus, 1920) was so great that in some areas efforts to breed these animals were discontinued.

Kalkus (1920) reported that 30 to 50 percent of adult horses in Washington had

visibly enlarged thyroids; goiters became apparent within a year after the animals were brought into the area. About 75 to 90 percent of foals showed extreme weakness and died 3 to 4 days after birth; the thyroids were only slightly enlarged. Dimock, et al., (1944) studied 59 adult equine thyroids at Lexington, Kentucky, and found evidence of hyperplasia in 33.9 percent and a colloid goiter in 6.7 percent. In an aged mare the thyroid bore a circumscribed adenoma. Over a period of 3 years Venzke and Mannasmith (1940) studied the thyroids of 51 horses from central Iowa and found only a single case of colloid goiter. Sattler (1952) cites 4 cases of thyrotoxicosis in horses. The diagnosis was based on the presence of goiter, exophthalmos, nervousness, and tachycardia. Reports of single cases of carcinoma of the thyroid in horses are scattered throughout the literature; Sticker (1902) collected 8 cases and reported 2 more.

Adult cattle rarely show gross evidence of goiter, but this is due in part to the loose skin about the neck that would conceal any but very large thyroids. Among newborn calves in regions where goiter is endemic, up to 70 to 80 percent may be born with enlarged thyroids (Kalkus, 1920); the majority of these survive and become normal adults. A few are nearly hairless and myxedematous; these are either stillborn or soon die. Welch (1928) pointed out that the incidence of this condition in calves from the same locality may vary greatly from year to year. Matthew and Thomas (1935) have reported goiter in the calves of a pure bred herd of Afrikander cattle in the Middle Eastern Cape Province, Union of South Africa. Four cases of bovine goiter with exophthalmos were listed by Sattler (1952). Induced hyperthyroidism is now being observed following the use of the commercial type of thyroprotein to stimulate milk production (Andrews, 1950).

Cancer of the thyroid is rare in cattle. Sticker (1902) was unable to find a single case in his review of the early literature. However, in a personal communication Lt. Col. T. C. Jones (1954) reported that there are 5 cases of bovine adenocarcinoma of the thyroid on file at the Armed Forces Institute of Pathology. In addition, a case of thyroid adenocarcinoma in a sheep and one in a swine are listed. The rare occurrence of thyroid cancer in cattle, sheep, and swine as compared with horses and dogs may be sought in the youthfulness of these animals at the time of slaughter. Dogs and horses are permitted to reach a relatively advanced age, more favorable for malignant change in the thyroid.

Adult sheep when taken to iodine deficient regions will acquire hyperplastic thyroids which later develop the flattened epithelium and accumulated inactive colloid characteristic of goiter. The newborn lambs show changes similar to those of calves, but the mortality is higher. The lambs have scanty wool, are myxedematous, and may have huge goiters that interfere with parturition (Kalkus, 1920; Welch, 1928). In areas such as Indiana, where iodine deficiency is less marked, woolless lambs are uncommon. Nevertheless, in lambs from a flock fed a ration not supplemented with iodine. Andrews, et al., (1948) found the average thyroid weight was 5.7 g. and epithelial hyperplasia was observed in over 60 percent of the glands. In a second flock fed iodized salt, only 1 of 86 glands was hyperplastic and none weighed more than 1.8 g. The first outbreak of congenital goiter among lambs in Britain occurred in 1945 when the offspring of 40 ewes were affected. Jamieson and Harbour (1947) reported that many were stillborn, had little wool, and had enlarged thyroids that reached the size of an orange. The authors suggest that a rich pregnancy diet of oats, beans and linseed cake may have been a factor, a possibility also entertained by Welch (1928) when a large number of previously normal lambs developed goiter on a fattening diet.

The economic loss from the death of newborn pigs in iodine deficient areas was very great before supplemental iodine was fed the sows. The young pigs are hairless, myxedematous, and often stillborn; the thyroid may be 2 to 3 times normal size, but Kalkus (1920) states that a visible swelling is usually absent. When the iodine deficiency is less pronounced Andrews, et al., (1948) observed that

of 111 glands from newborn pigs 39 percent contained only a trace of iodine and over 30 percent were hyperplastic. When the diet of the sows included supplemental iodine, only 14 of 106 glands from the shoats contained less than 0.2 g. percent iodine and none was hyperplastic.

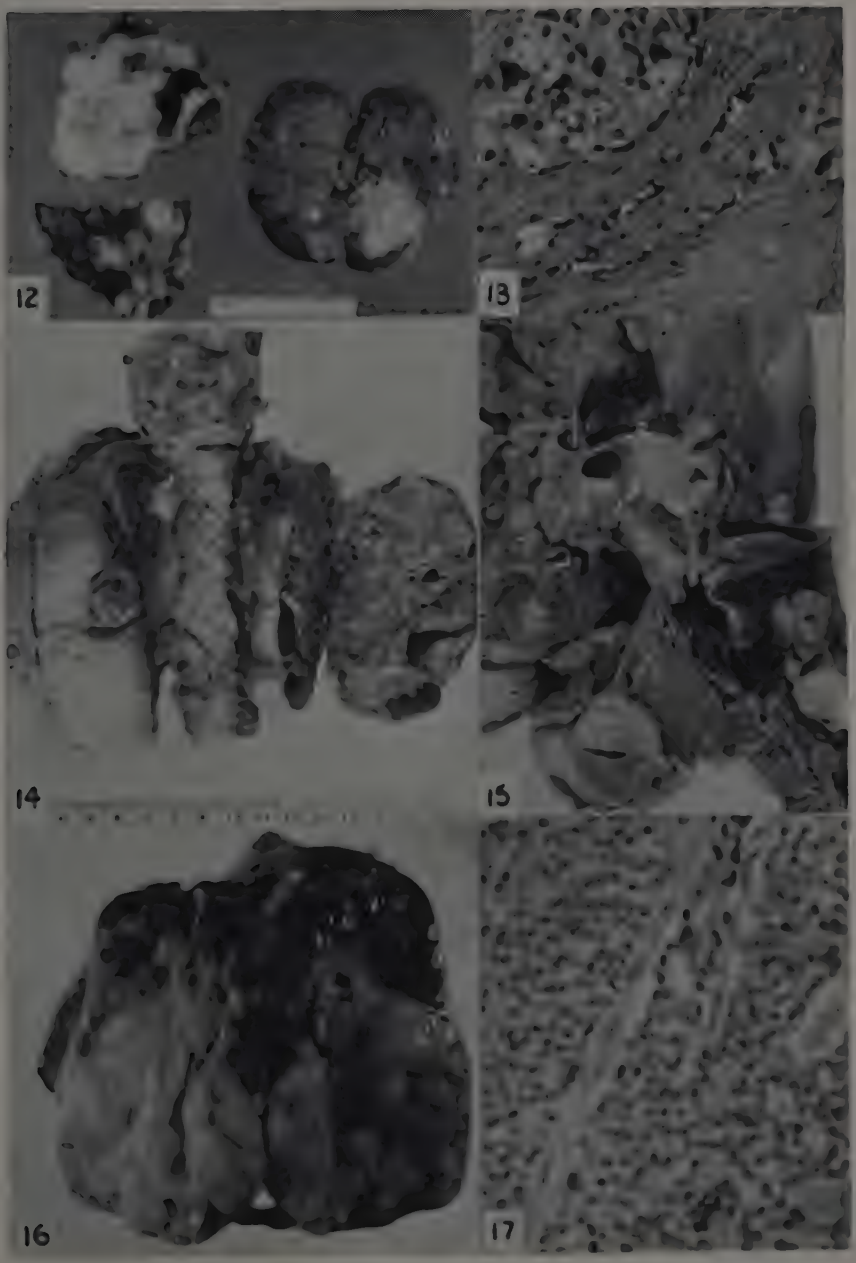
Goats are extremely susceptible to goiter. Kalkus (1920) observed that adults may have markedly enlarged glands but appear unaffected; the kids, however, are hairless and stillborn or die within a few hours. In the mountains of southern Germany half the goiterous kids die of suffocation due to pressure of the enlarged thyroid on the trachea (Koch, 1944). In a histological study of the thyroids of newborn hairless goats Baumann (1948) observed that the glands are larger than those of newborn pigs with myxedema and show considerable colloid storage.

Another domesticated ungulate, rarely seen outside zoos in this country, is the camel. In his treatise on the humped camel, Leese (1927) emphasizes the occurrence of congenital goiter among the young, born of dams during long sea voyages or when confined in zoological gardens. The thyroids may be enormously enlarged at birth, and death from suffocation may occur shortly after delivery. The animal may survive and the goiter persist throughout life, or even become larger. Kitt (1916) cites the case of a goiterous camel at the Dresdon Zoo; her young always had congenital goiter, whereas other camels and dromedaries housed in the same building were free of goiter and bore normal young. An instance of congenital goiter in a dromedary was encountered in the New York Zoological Gardens and described by Finkelstein (1939). The full term macerated fetus could not be delivered because of a large mass in its neck that necessitated embryotomy. Each lobe of the thyroid measured $25 \times 15 \times 8$ cm.; death of the fetus may have been due to compression of the carotid arteries by the gland. The goiter was cystic and contained abundant colloid, unlike the hyperplastic thyroids found in congenital goiter of other species. Over a year later the dam died of an infection; at autopsy a moderately enlarged thyroid was found, the epithelium was hyperplastic.

Unlike the occurrence in ungulates, congenital goiter does not play a prominent role in thyroid dysplasia of the dog and cat—our domesticated carnivores. Nevertheless, Carlson (1914) recognized congenital thyroid hyperplasia in these animals when the mothers had hyperplasia thyroids. Before the introduction of prepared dog food and iodized salt, Marine and Lenhart (1909) found that goiter was very common among dogs reared in the so-called goiter belt of this country. Schlotthauer, et al., (1930) examined 234 thyroids from dogs of southern Minnesota. Among these they found 54 diffuse colloid goiters, 14 nodular colloid goiters, and 2 instances of carcinoma. The occurrence of exophthalmic goiter has been reported several times; 4 cases were collected from the literature by Sattler (1952). One of these was a male pointer that developed a goiter as large as a child's head in which pulsation and thrill was noted on palpation. The animal acquired a pronounced bilateral exophthalmos and marked muscle tremor.

EXPLANATION OF FIGURES IN PLATE III

12. Carcinoma of the thyroid in a dog. The tumor is seen in cross section to have partly encircled the trachea. Multiple metastases are present in the kidney.
13. Histological section showing poorly differentiated carcinoma invading connective tissue. Mag. X 140.
14. Carcinoma of the thyroid in a wolf, *Canis mexicanus*.
15. Multiple metastases to the lungs of the animal shown in Fig. 14. Philadelphia Zool. Soc. No. 7203.
16. Carcinoma of the thyroid in a leopard, *Felis pardus*. The tumor, which entirely replaced one lobe of the thyroid, measured 10 cm. in diameter.
17. Section of carcinoma showing poorly differentiated follicles and sheets of neoplastic epithelial cells. Mag. X 85. Philadelphia Zool. Soc. No. 14884.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There are many reports of carcinoma of the thyroid in dogs; several accounts record numerous cases and review the literature (Wondenberg, 1909; Ewald, 1915; Stunzi, 1947; Mulligan, 1949). In 8 cases of thyroid carcinoma Davis (1938) found metastases in both lungs and frequent invasion of the thyroid and pulmonary veins. The tumor is often firmly adherent to the trachea and partly encircles it (fig. 12). In one instance a polypoid structure in the right auricle proved to be metastatic thyroid carcinoma. The problem of so-called aberrant thyroid tissue which has been such a source of confusion in studies of human thyroid carcinomas has also troubled investigators of the canine neoplasms (Davis, 1938). The histology of the carcinoma is often that of a poorly differentiated adenocarcinoma. The cells frequently form solid sheets that infiltrate the adjacent tissues (fig. 13); venous invasion is common. The neoplastic epithelial cells occasionally become spindle-shaped and closely resemble a sarcoma (Slye, et al., 1926); this simulated carcinosarcoma is also found in human cases. Occasionally an unusual histological variant has been described; e.g., the mixed carcinoma and chondrosarcoma reported by Mason and Wells (1929).

Goiter is much less often reported in cats than in dogs. That this probably reflects a real difference in susceptibility between the two animals is indicated by reports of investigators like Carlson (1914) who examined hundreds of cats and dogs in his physiological studies and concluded that cats are much less subject to pathological changes of the thyroid than are dogs. Carlson found thyroid hyperplasia, but rarely colloid goiter in cats from the Chicago area. According to Crotti (1938) goiterous cats have also been seen along the banks of the Gunduk River in India. Huguenin (1927) found adenomas in the thyroid 3 times in 3,000 autopsies on cats. A single case of adenocarcinoma of the thyroid in a cat is in the collection of the Veterinary Pathology Section of the Institute of Pathology, Washington, D.C., as compared with 17 cases of thyroid carcinoma in dogs (Jones, 1954).

LABORATORY RODENTS

Interest in hyperplasia and neoplasia of the thyroid in laboratory rodents has increased during the past decade because of the ease with which these changes can be induced experimentally with thiocyantes and thiouracils. An extensive literature has arisen that will not be reviewed here. An early monograph on spontaneous goiter in albino rats was written by Langhans and Wegelin (1919); more recently McCarrison (1930) in India reported 148 cases of goiter among 2,168 albino rats on various vitamin deficient diets. Of these rats 56 were males, 92 females; goiters appeared most commonly at the time of maturity. Slye, et al., (1926) found 5 cases of sarcoma of the thyroid in rats reported in the literature and contributed one case of carcinoma. The latter developed in a wild female Norway rat caught when young and kept in the laboratory for 3 years and 4 months. Shortly before death symmetrical enlargements were seen in the neck. Histologically the tumor proved to be a papillary adenocarcinoma. Among nearly 3,000 rats Bullock and Curtis (1930) observed 521 primary spontaneous tumors; of these, only 2 occurred in the thyroid. One was a fibroadenoma, the other a carcinoma. The latter was a poorly differentiated adenocarcinoma that measured $9\times5\times5$ mm. and occupied the left lobe of the thyroid in a 948-day-old female. Despite this infrequency of spontaneous tumors of the thyroid in the rat it is interesting to note that hyperplasia and neoplasia occur readily following the use of drugs that inhibit formation of thyroid hormone.

Among 61,000 necropsies on mice with over 5,000 spontaneous malignant tumors, Slye (1927) found only 23 animals with thyroid enlargements. Of these, 4 were simple colloid goiters, 2 were papillary adenomas, and 17 were malignant growths. Of the latter, 11 occurred in a single strain of Japanese waltzing mice; no simple adenomas or goiters occurred in the strain, of which 8.2 percent of the

deaths were due to thyroid cancer. On microscopic appearance the tumors were identified as carcino-sarcomas. In 5 other strains of waltzers no thyroid tumors appeared. Besides the waltzers, malignant tumors of the thyroid were found in only 3 other strains of mice among hundreds of strains carried in the laboratory. The author concluded that in the waltzing mice the tumor appeared as a simple Mendelian recessive; resistance to thyroid malignancy was dominant.

Endemic goiter reported in a rabbit colony by Chesney, et al., (1928) subsequently proved to be due to cyanates in the fresh cabbage that had been a daily article of diet. Whereas the top normal weight of a rabbit thyroid was 2.0 g., the rabbits with goiter had glands that weighed up to 36 g.

CAPTIVE WILD MAMMALS

Most of the data for this discussion of thyroid lesions in captive wild mammals was obtained from autopsy reports of deaths at the London and Philadelphia Zoos. Dr. Herbert L. Ratcliffe, director of the Penrose Research Laboratory of the Philadelphia Zoological Gardens, was very generous with his time and material.

The distribution of goiter and thyroid carcinoma among the various orders of captive wild mammals shows a marked predominance of the carnivores (table 2).

TABLE 2

Distribution of thyroid lesions among mammalian orders

ANIMAL ORDER	GOITER			CARCINOMA		
	Lond.Z.Soc. 1926–1946*	Phil.Z.Soc. To 1923+	Phil.Z.Soc. 1923–1953§	Lond.Z.Soc. 1926–1946*	Phil.Z.Soc. To 1923+	Phil.Z.Soc. 1923–1953§
Carnivora	13	31	22	4	3	5
Rodentia	6	0	9	2	1	1
Marsupialia	1	7	0	0	0	0
Menotremata	1	0	0	0	0	0

*Cases reported in Proceedings of the London Zoological Society.
Cases reported in Fox's "Disease in Captive Wild Mammals and Birds."
§Personal communication, Dr. Herbert L. Ratcliffe.

This is particularly striking when contrasted with the absence of such lesions among the hoofed mammals, whereas in domestic animals the ungulates are most affected. Ratcliffe (1954) has suggested that this may in part be due to the ease of administering iodine in "salt licks" compared with the difficulty of including it in the diet of certain carnivores such as lions and tigers. The thyroid abnormalities are particularly common in old animals that can reach advanced age because of their protective custody in a zoo. Fox (1923) stated that the normal thyroid of carnivores is relatively larger than that of ungulates; carnivores have 0.55 g. of thyroid per kg. body weight, ungulates 0.18 g., and marsupials 0.44 g.

Among the carnivores the *Canidae*, relatives of the dog, such as the coyote, wolf, and fox, frequently exhibit goiter or thyroid carcinoma (tables 3 and 4). One of these was an 8-year-old female wolf, *Canis mexicanus*, born at the Philadelphia Zoo; she had always received supplementary iodine in her diet. At autopsy Ratcliffe (1954) found a massive carcinoma of the thyroid with extensive metastases to both lungs (fig. 14 and 15). Histologically the tumor was composed of sheets of poorly differentiated epithelial cells without evidence of follicle formation or colloid secretion.

Among the bears, *Ursidae*, goiter is not uncommon (table 3). Hackel (1954) found a nodular goiter in a male European Brown Bear, *Ursus arctos*, that was

sacrificed at the Cleveland Zoo because of old age. At the same institution he and co-workers (1953) found a carcinoma of the thyroid in a male Malayan Sun Bear, *Helarctos malayanus*, that was known to be over 20 years of age. The thyroid was greatly enlarged and nodular, but was not adherent to surrounding structures and did not obstruct the trachea. Microscopic examination disclosed a well differentiated adenocarcinoma that had metastasized to the regional lymph nodes.

The big cats, *Felidae*, e.g., lion, tiger, and leopard, appear prone to develop goiter (tables 3 and 4); among the older animals carcinoma of the thyroid is not

TABLE 3

*Species distribution of thyroid lesions at the Philadelphia Zoo, 1923–53**

SPECIES	GOITER	CARCINOMA
Coypu, *Myocaster coypus*	9	1
Polar bear, *Thalarctos maritimus*	2	0
Black bear, *Ursus americanus*	2	0
Coyote, *Canis larus*	3	1
Grey wolf, *Canis mexicanus*	2	2
Red fox, *Canis vulpes*	3	0
Lion, *Felis leo*	5	0
Leopard, *Felis pardus*	2	1
Tiger, *Felis tigris*	3	1
	31	6

*Personal communication, Dr. Herbert L. Ratcliffe.
"Goiter" includes hyperplasia with enlargement.

TABLE 4

Species distribution of thyroid lesions at the London Zoo, 1926–46

SPECIES	GOITER	CARCINOMA
Coypu, *Myocastor coypus*	5	2
Fox, *Vulpes vulpes*	3	3
Racoon, *Procyon lotor*	2	4
Coati, *Nasua narica*	0	2
Lion, *Felis leo*	3	0
Kusimanse, *Crossarchus obscurus*	2	0
Others	6*	5**
	21	16

*Dingo, fossa, badger, mouse, wombat, echidna.
**Otter, hutea, wolf, cape dog, genet.

uncommon (table 3). A case of congenital goiter in a young leopard, *Felis pardus*, was reported by Sklower (1926). The animal lived only 10 days and had gradually increasing difficulty in swallowing; external examination showed enlargement of the neck in the region of the thyroid. At autopsy a large diffuse colloid goiter was found. In a male leopard, *Felis pardus*, exhibited for over 19 years at the Philadelphia Zoo a carcinoma was found to replace most of the thyroid gland (fig. 16). Metastases were present in the cervical lymph nodes and kidneys. Most of the tumor was composed of sheets of poorly differentiated epithelial cells, but in some areas follicle formation was still apparent (fig. 17). In an aged black

leopard at the Cleveland Zoo, Hackel (1954) found a 1 cm. firm gray nodule in each lobe of the thyroid. Microscopically these had the appearance of adenocarcinoma; metastases were present in the cervical lymph nodes. Although at both the London and Philadelphia Zoos nearly every lion, *Felis leo*, at autopsy showed thyroid hyperplasia with some enlargement and occasional adenoma formation, a malignant change was not seen. Three tigers, *Felis tigris*, at the Philadelphia Zoo showed hyperplasia and enlargement of the thyroid; 2 of these, both males, had been exhibited for 8 and 14 years, respectively; the third was a young female only 1½ years of age. In a male tiger over 17 years old a poorly differentiated carcinoma of the thyroid was found at autopsy; metastases were present in the kidneys (Ratcliffe, 1954).

A surprising incidence of goiter and thyroid carcinoma was found in the small carnivors of the family *Procyonidae* at the London Zoo. This includes the racoons, *Procyon*, of North America and the coatis, *Nasua*, of South America. Among these animals there were 6 cases of thyroid cancer (table 4). Metastases were present in the lungs of all 4 racoons and in the lungs of 1 of the 2 coatis (Scott, 1928; Hamerton, 1935, 1938, 1944). This animal, a ringtailed coati, *Nasua nasua*, had been on exhibition in the zoo for 9 years.

A few cases of thyroid carcinoma have also been found in the *Viverridae*, a family of small catlike carnivores like the civet. Scott (1928) described an adenocarcinoma of the thyroid in a pardine genet, Genetta pardina; and Purmann (1929) reported the case of a *Viverricula malaccensis* in which the primary carcinoma of the thyroid had metastasized to the lungs. The animal had been exhibited at the Vienna Zoo for 20 years.

Thyroid lesions are uncommon in captive ungulates; however, goiter is occasionally found; e.g., in camels (see above). Kitt (1916) cites the case of a newborn giraffe at the Dresden Zoo with a 3,600 g. goiter. The giraffe mother also had a fist-sized goiter and once before had been delivered of a goiterous calf. The sporadic character of endemic goiter is shown in the account by Seeberger (1923) of his experience with a colony of Alpine ibex, *Capra ibex*, in a park at St. Gallen, Switzerland. Of the 10 ewes 5 had goiterous young; the latter were stillborn or died in the neonatal period. Only 2 of these 5 ewes had grossly visible goiters; the rams showed no enlargement of the gland. The animals were kept in the same environment and given the same food and water—all Swiss water is poor in iodine, 0.2 to 1.5 μg./kg. (McClendon, 1939). After the adults were fed iodized salt none of the young were born with goiter. Kalkus (1920) has pointed out that wild deer in some regions of Washington, where goiter was common in sheep and cattle, were free of the disease. He attributed this to the observation that deer and other wild animals frequented so-called "licks" and ate the soil which had 0.032 percent iodine (no unit given) as compared with 0.0015 percent for that of the pastures. Finally, mention may be made of a goiterous antelope found in Siberia near the Chinese frontier and identified as a distinct species, "antelope gutturosa", by Radde. Crotti (1938), who cites the instance, points out that goiter is endemic in this region and that the enlarged thyroid is merely an adaptive response to the environment rather than a species characteristic.

Of the rodents autopsied at the London and Philadelphia Zoos the coypu, *Myocastor copyus*, had the highest incidence of goiter and thyroid carcinoma (tables 3 and 4). This is an animal that resembles the muskrat in appearance and behavior; it is a native of South America and the plucked fur is known in commerce as "nutria." In Philadelphia the average exhibition period of the animals showing thyroid hyperplasia was 2 years; most were killed by cage mates in the numerous fights that occurred. Although hyperplasia of the thyroid with slight enlargement was common, large goiters such as those found in the London Zoo (Hamerton, 1933) were not seen. In London the animals were older, up to 7½ years, and goiters the size of a tangerine were occasionally present. The

single example of cancer of the thyroid in a coypu at the Philadelphia Zoo occurred in an animal that was over 4 years old. Both cases of thyroid carcinoma seen at the London Zoo showed pulmonary metastases (Hamerton, 1936, 1939).

Fox (1923) reports 7 cases of nodular colloid goiter among marsupials in the Philadelphia Zoo. Four of these were in the carnivorous opossums, *Didelphys virginiana*, and Tasmanian devils, *Sarcophilus ursinus;* the remaining 3 occurred in herbiverous kangaroos. A Tasmanian wombat, *Phascolomys tasmaniensis*, one of the burrowing marsupials, died at the London Zoo. Autopsy by Hamerton (1935) disclosed an enlarged cystic thyroid the site of acute suppurative inflammation. Pettit (1900) described a carcinoma of the thyroid in an opossum, *D. virginiana*, exhibited at the zoological garden of the Museum of Natural History in Paris. Although the tumor did not metastasize it appeared to be malignant on histological examination. Solid sheets of neoplastic epithelial cells showing no evidence of follicle formation or colloid storage made up the bulk of the tumor.

The lowest order of mammals is represented by the egg-laying monotremes. The thyroids in these animals are paired, as they are in amphibians, most reptiles, and birds. Only a single report of thyroid enlargement was found in the literature (Hamerton, 1944). An echidna, *Zaglossus bruijnii*, had been exhibited in the London Zoo for 30 years when it died. At autopsy the left gland was a cystic nodular goiter approximately 3 cm. in diameter; the right thyroid measured about 8 mm. in length and was of normal size.

SUMMARY

Enlarged hyperplastic thyroids and colloid goiters have been found in fishes, reptiles, birds, and mammals. In nearly every instance the animals were in an unnatural environment; viz., fish in hatcheries or aquaria, reptiles in zoological gardens, birds and mammals under domestication or in captivity. Cancer of the thyroid occurs under the same conditions and in the same animal species as does thyroid hyperplasia and goiter; the animals affected with cancer are usually older than those with goiter. There is evidence that the cancers often arise in a previously hyperplastic or goiterous thyroid.

The fishes most commonly affected with goiter are the *Salmonidae*, particularly brook trout when reared in hatcheries. Salt water fish, though rarely affected, may show evidence of goiter if kept in poorly aerated or polluted water with a relatively low iodine content. The difference in species susceptibility to goiter is also apparent in these fishes, for the pilot fish, *Echeneis naucrates*, is particularly prone to develop the lesion.

The absence of reported instances of goiter among the amphibians is probably due in part to the small numbers of these animals that as adults are kept in captivity for long periods. The fact that their thyroid can respond to goiterogenic drugs would indicate that under conditions of iodine insufficiency thyroid hyperplasia and goiter formation would occur.

Only 3 cases of goiter in reptiles have been reported, but here again the factors discussed for amphibians mediate against the frequent occurrence of this lesion.

Among birds goiters have been observed in fowl and pigeons and in a small number of birds in zoological gardens. Shell parrakeets, *Melopsittacus undulatus*, have been received in this laboratory from many parts of the country. Twenty-three of the birds, all from low-iodine areas, had hyperplastic thyroids. Some of the glands were only 2 or 3 times normal size, but most were very large and cystic goiters. All but 2 of the birds were females. In the Philadelphia Zoo 3 cases of cancer of the thyroid were seen by Dr. Herbert Ratcliffe, 2 in psittacine birds and 1 in a duck.

Goiter in domestic animals presented serious problems in the Northwest, but these are now largely overcome by the use of iodized salt. Adult cattle, sheep, goats, and swine were not seriously affected; but the newborn were often

hairless, myxedematous, and stillborn or died shortly after birth. Large goiters in the fetus occasionally interfered with parturition. Dogs rarely are affected by congenital goiter, although enlarged thyroids and even carcinoma are not uncommon in the adult. Cats seldom have grossly enlarged thyroids.

In zoological gardens the carnivores are more often goiterous than any other mammals. Among these, lions, tigers, leopards, wolves, bears, and racoons are frequently affected. The coypu, a rodent, and some of the marsupials also show a high incidence of goiter. Cancer of the thyroid has been reported in all these animals. The ungulates and primates in zoos are remarkedly free of goiter.

There is a relatively high incidence, particularly among mammals, of thyroid cancer in species that frequently exhibit goiter or other evidence of thyroid hyperplasia. It would appear that in these animals the hyperplasia may be a precursor of cancer.

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ERRATA

In the article by August C. Mahr in the Ohio Journal of Science, 54: 1954, in line 27 on page 380, read, " . . . Harvard University Library," (for " . . . Howard University Library").

CHEMICAL DATING OF BRONZE COIN BLANKS FROM THE ATHENIAN AGORA[1]

EARLE R. CALEY AND WALLACE H. DEEBEL
Department of Chemistry, The Ohio State University, Columbus 10

In the summer of 1953 excavators at the Agora in Athens, Greece, found a mass of small pieces of bronze covered with corrosion products immediately below the ancient ground level just outside the corner of the foundations of a destroyed building that was suspected to have been the ancient mint of Athens. After cleaning, eight of these pieces were seen to be thick round discs, two of the pieces similar imperfect discs, and the remaining piece a short length of rod from which the discs had obviously been cut. Light facets on the edges of the discs and on the side of the piece of rod showed that the original rod had been formed by forging. The diameter of the eight complete discs varied from 12 to 14 mm. and the thickness from 7 to 10 mm., their average thickness being 8 mm. These discs ranged in weight from 5.5 to 7.7 g., the average being 6.5 g. Discs such as these have long been recognized as blanks for the striking of coins, and have been found in similar situations at other sites. For example, 43 bronze discs were found in the ruins of a building thought to have been the ancient Greek mint at Chersonesos Taurika in the Crimea (Thompson, 1954).

TABLE 1

Analysis of coin blank

SAMPLE	CU	AG	AU	SN	PB	FE	NI	ZN	TOTAL
No.	%	%	%	%	%	%	%	%	%
1	66.70	0.07	trace	7.22	25.46	0.14	0.07	0.12	99.78
2	66.37	0.10	trace	6.95	25.80	0.12	0.07	0.07	99.48

Dr. Homer A. Thompson of the Institute for Advanced Study at Princeton, present director of the Agora excavation project, sent one of the imperfect discs to the senior author for chemical analysis in the hope that this would provide an independent confirmation of the antiquity of the bronze. Results of the analysis by the junior author of two clean samples weighing 1.1624 and 1.2987 g., respectively, are shown in table 1. These results show that the bronze from which these samples came is undoubtedly ancient. The presence of gold and silver is very indicative of antiquity, and the proportion of nickel is characteristic of ancient Greek bronze, especially ancient Greek coinage bronze. In a series of bronze coins of Athens the senior author and co-workers found an average of 0.05 percent nickel, and for coins of various other localities in Greece an average of 0.06 percent (Caley, 1939). The low summations indicate the presence of undetermined oxygen and perhaps other impurities in higher proportion than would ordinarily be found in modern bronze. The lack of agreement in the summations and in the percentages of copper, tin, and lead for the two carefully performed duplicate analyses are indicative of a greater degree of heterogeneity than would normally exist in modern metal. Also significant are the high percentages of lead coupled

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with moderate percentages of tin. Such proportions are not found in modern bronzes, but are similar to those that have been found in Athenian coinage bronzes of a certain period. This similarity may be seen by comparing the figures in table 1 with those in table 2, which contains a listing in chronological order of

TABLE 2

Percentage of principal metals in certain Athenian bronze coins

No.	DATE	WEIGHT GRAMS	CU %	SN %	PB %
1	III Century B.C.	6.0	89.64	10.40	0.01
2	" " "	7.8	89.54	9.40	0.54
3	II " " "	6.5	88.74	11.10	0.22
4	" " " "	5.9	86.38	10.56	2.73
5	I " " "	5.1	73.16	7.54	18.82
6	" " " "	5.2	71.23	6.84	20.38
7	" " " "	6.3	70.25	6.29	22.73
8	I–II " A.D.	5.0	68.05	4.45	26.82
9	II " " "	5.4	63.23	3.89	32.51
10	II–III " " "	5.4	66.05	4.10	29.32
11	III " " "	5.0	66.19	3.75	29.18

the percentages of copper, tin, and lead in all Athenian coins weighing at least 5 g. but less than 8 g. that have been analyzed up to now by the senior author and his co-workers. This series is restricted to coins of this range of weight for the sake of brevity and because the coin blanks are within this range. However, inclusion of all coins that have been analyzed would have shown about the same differences and similarities. On the basis of their types or other available information, none of these coins could be dated with any certainty closer than the century in which they were struck.

TABLE 3

Ratio of percentage of lead to percentage of tin

SPECIMEN	Pb/Sn RATIO
Coin No. 1	0.00
Coin No. 2	0.06
Coin No. 3	0.02
Coin No. 4	0.26
Coin of about 88 B.C.	1.75
Coin No. 5	2.50
Coin No. 6	2.98
Coin No. 7	3.61
Coin Blank	3.62
Coin of I Century A.D.	3.88
Coin No. 8	6.03
Coin No. 9	8.36
Coin No. 10	7.15
Coin No. 11	7.78

In view of the systematic chronological changes in the proportions of lead and tin that have been shown to exist in ancient Greek coinage bronze in general (Caley, 1939) and in Athenian coinage bronze in particular, it is possible not only to confirm the antiquity of these coin blanks by chemical analysis but to establish also the approximate date of their manufacture. Of greater chronological

significance than the order of the percentages of lead and tin are the ratios of the percentages of these metals. In table 3 are shown the ratios of the percentages of lead to tin for the coins listed in table 2. Included also in table 3 are ratios for two additional coins, one of which could be dated from its type almost to the year of its coinage and the other definitely within the first century A.D. These coins are included because they furnish needed fixed points on the time scale, even though their weights fall outside the range of the weights of the blanks. The ratio shown for the blank that was analyzed is an average figure, the individual ratios for the two analyses being 3.53 and 3.71 respectively. It seems significant that the weight of Coin No. 7 is very close to the average weight of these blanks and that the ratio for this coin is almost identical with the average ratio for the blank that was analyzed. This suggests that these blanks may have been intended for coins of this type. At least, from the information at present available, it is the only type of coin that could have struck from these blanks. From the position of the average ratio and the individual ratios for the blank in this series it appears evident that these coin blanks were made in the latter part of the first century B.C., and it seems probable that the date 25 B.C. would not be in error by more than 25 years either way. This suggested date falls well within the broad general period indicated by the archaeological observations, and indeed serves to fix the time at which these coin blanks were discarded, hidden, or lost more precisely than is possible from these observations.

As far as the authors are aware, this is the first attempt to date ancient coin blanks from internal evidence. The success of this attempt suggests the possibility of dating by this same method ancient coins that are illegible because of wear or corrosion. Since coin blanks are rare and illegible coins abundant, the dating of such coins should be the more frequent application of this method of chemical dating in the future.

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The Major Features of Evolution. *G. G. Simpson.* Columbia University Press, New York 1953. xx +434 pp. $7.50.

The purpose of this book is "to consider and to try to explain some of the major features of the evolution of life": an exposition of "four-dimensional biology". A partial list of chapter titles indicates the "major features" considered: Rates of Evolution; Variation; Mutation; Population and Selection; Adaptation; Trends and Orientation; Extinction, Relicts, and Irreversibility; Higher Categories; and Patterns or Modes of Evolution. The book is the offspring of and successor to TEMPO AND MODE IN EVOLUTION, and contains much reworked material from that book. As the list of subjects shows, this work is much broader in scope, and is able to take advantage of much that has been learned since the earlier work. As a writer of science Simpson has few peers, and the purpose of this book is accomplished with his customary clarity and brilliance. He is particularly effective in the defense of the development of characters and groups through gradual accumulation and the refutation of the notion of their catastrophic appearance more or less *de novo*. Equally effective are his thrusts at vitalist and finalist theories of orientation of evolution. The book is an indispensable reference work for the practicing biologist or paleontologist who is concerned with anything more than pigeon-hole taxonomy. It should be assigned for reference, if not as a text, to students in courses on evolution and majors in biology or paleontology.

MALCOLM P. WEISS.

PHYSIOLOGICAL PROCESSES ASSOCIATED WITH SPERM EMISSION IN THE LEOPARD FROG, *RANA PIPIENS*[1]

M. L. GILTZ

Department of Zoology and Entomology, The Ohio State University, Columbus 10

The male frog test for pregnancy, announced by Wiltberger and Miller (1948), and Robbins and Parker (1948), has caused some investigators to try to determine the nature of the physiological processes involved in the emission of the spermatozoa. Among these were Robbins and Parker (1949) who reported the emission of spermatozoa following injections of adrenergic substances; Giltz and Miller (1950) who noted the emission of spermatozoa following the injection of distilled water, pond water or tap water in amounts exceeding 20 percent of the body weight of the frog; Biesinger and Miller (1952) who studied histological sections of the testes before and after injections of pregnancy urines; McCourt (1953) who sectioned the testes longitudinally and found that there is an anterior-posterior gradient of the mature tubules of the testes; and Kissen (1954) who reported the emission of spermatozoa in the urines of hypophysectomized frogs following the injection of either pregnancy urines or anterior pituitary-like hormones.

Notwithstanding these investigations on *Rana pipiens*, and the inferences to be drawn from earlier work on pituitary-gonad relationships of other species of frogs, which was summarized by Houssay (1949), the exact manner in which gonadotropins influence the urogenital system was not yet determined. It is not generally believed that adrenergic agents, water, pituitary substances, and the pregnancy urine hormone would produce the same physiological effects upon all animal tissues, yet the effects of these substances upon the frog are all correlated with the emission of spermatozoa in its urine.

The results of the following investigation help to clarify the part which the above substances play in bringing about the movement of spermatozoa from the testes to the bladder. The first area of investigation was devised to study excised testes, which were observed in order to determine whether there was an emission of spermatozoa from the testes into various fluids in which they were immersed. The second area of investigation involved a study of testes in situ following gonadotropic and non-gonadotropic subcutaneous injections. The third area of investigation involved frogs which had partial or entire brain extirpations preceding subcutaneous injections of either gonadotropic or non-gonadotropic substances.

Materials. The frogs used in these experiments were the leopard frog, *Rana pipiens*, procured from commerical suppliers. They were stored in groups of 25 in small aquaria in a refrigerator at approximately 45° F. Ayerst brand of chorionic gonadotropin ("APL") was used. It contained 100 international units (I.U.) per cc. of solution. It was diluted with distilled water or saline solution according to the number of international units desired for the various experiments. The saline solution used was Ringer's solution for cold blooded animals, prepared according to Lee (1950). The adrenalin used was Parke, Davis and Company, 1: 1000. The human pregnancy urines (H.P.U.) were from samples submitted for pregnancy diagnosis.

The emission of spermatozoa from excised testes. Glass and Rugh (1944), Biesinger and Miller (1952), and McCourt (1953), have made histological studies of testicular tissue which was removed from treated and untreated frogs. In these studies a change in position of spermatozoa from the periphery of the

[1]From a dissertation presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate School of the Ohio State University.

tubules, where they are attached to Sertoli cells, to the center of the tubules, where they are usually free from the Sertoli cells, was associated with the injection of gonadotropins. However, the association of this reaction with injections does not preclude the possibility that the injections act on some structure other than the testes. In my study experiments were devised to determine whether gonadotropins have an effect upon the movement of spermatozoa from the Sertoli cells at the periphery to the lumen of the tubules and out of the excised gonads.

Before the testes were excised various solutions were prepared, and one cubic centimeter of each solution was placed in a concavity slide. The solutions were: saline, distilled water, frog urine, frog plasma, human pregnancy urine, human non-pregnancy urine, saline plus various amounts of anterior pituitary-like chorionic gonadotropin, distilled water plus various amounts of anterior pituitary-like chorionic gonadotropin, saline plus various amounts of adrenalin, and distilled water plus various amounts of adrenalin. Each excised gonad was placed in a concavity slide containing one of the solutions. and care was taken to insure their

TABLE 1

The effect on emission and motility of spermatozoa obtained when excised testes were immersed in various solutions

Approx. No. of Trials	Immersion Solution	Effect	
		Emission of Spermatoza	Motility of Spermatoza
150	Distilled water	Positive	Positive
10	Tap water	"	"
70	Frog urine	"	"
70	Distilled water plus A.P.L.	"	"
50	Distilled water plus adrenalin	"	"
10	50% saline and 50% distilled water	"	"
150	Saline	Negative	Negative
70	Saline and A.P.L.	"	"
50	Saline plus adrenalin	"	"
35	Pregnancy urine	"	"
25	Fluid found in body cavity of frog	"	"
35	Lymph	"	"
25	Serum	"	"

submergence. Each preparation was examined microscopically for emerging or emerged spermatozoa. When this examination revealed that spermatozoa were streaming constantly or intermittently from the testes, the observation of that testis was recorded as positive. When the spermatozoa in the immersion fluid were motile it was recorded as positive for activity. When spermatozoa did not emerge from a testis the observation of that testis was recorded as negative. At times a few (2 to 50) spermatozoa were present from manipulation when the solutions were first observed. These had to be discounted in the results on emission but a record was made of their motility. Spermatozoa were motile if emission was taking place and immotile if emission was not taking place.

The experiments on emission were carried out during the months from February to November inclusive, at temperatures between 50° and 95° F. Neither season nor temperatures between these degrees appeared to influence the number of testes responding to treatment, nor did they influence the degree or number of spermatozoa which were motile. Investigators using intact frogs have found a seasonal sensitivity to gonadotropins (Sampson 1950). It was also shown that fewer

frogs emitted spermatozoa if the temperature of the room in which they were kept following the injections was above 80° F (Giltz and Miller 1950). Since season and temperature affect the emission of spermatozoa from intact frogs and not from excised testes it must be concluded that seasonal and temperature differences are due to an affect on structures other than the testes.

The experiments summarized in table 1 show that spermatozoa flow out of testes when placed in distilled water, tap water and frog urine. Water is obviously hypotonic to frog blood, and the urine of the frog is normally very dilute (Prosser *et al.*, 1950). Adolph (1927) found that the urine of *Rana pipiens* is strongly hypotonic to other body fluids even when the frog is in a hypotonic medium. Therefore, the fluids which are associated with the emission of spermatozoa are all hypotonic to the blood of the frog.

From the data in table 1, it is also shown that spermatozoa do not flow out of testes placed in saline solution, frog lymph, frog serum, fluids sometimes found in the frog's body cavity, and human pregnancy urines. It also indicates that the addition of anterior pituitary-like hormone and adrenalin to these solutions does not stimulate the emission of spermatozoa. These fluids into which spermatozoa do not flow from the testes are all isotonic or hypertonic to the blood of the frog.

TABLE 2

Effects of various solutions on the size of excised testes

Number Testes	Solution in Which Testes Were Immersed	Effect of Immersion on Sizes of Testes	Spermatozoa Emission
24	Saline	No increase	Negative
12	Saline plus adrenlin	"	"
24	Saline plus A.P.L.	"	"
20	Human pregnancy urine	"	"
12	Frog blood serum	"	"
18	Frog lymph	"	"
9	Fluid sometimes found in body cavity	"	"
14	Distilled water plus adrenlin	Increase	Positive
24	Distilled water plus A.P.L.	"	"
27	Distilled water	"	"
16	Frog urine	"	"

Since spermatozoa do emerge from excised testes immersed in hypotonic solutions and do not emerge in isotonic or hypertonic solutions regardless of the addition of pharmaceutical substances, it is concluded that the hypotonicity of the fluid is the dominating factor in the release of spermatozoa from excised testes.

The volume of excised testes associated with the emission of spermatozoa. During the experiment on the emission of spermatozoa from excised testes it was noticed that the testes which emitted their spermatozoa appeared to increase in size. It was also noted that testes, which at the beginning of the experiment were smaller at one end than the other, became more symmetrical when they were submerged in solutions into which they discharged their spermatozoa.

If there was an actual increase in size it would lend support to the hypothesis that diffusion into testicular tissue was taking place when the testes were subjected to solutions which are hypotonic to body fluids of the frog. Therefore, experiments were devised to determine whether there is an increase in the volume of excised testes which can be correlated with the emission of spermatozoa. These testes were measured at the time they were immersed in the various solutions and again after an interval of an hour in the solutions. The measurements were made by placing the concavity slide containing a testis on a millimeter rule and reading the

length and width from the sides and ends of the testes through a monocular microscope.

The results of the measurements are summarized in table 2. When the testes were placed in saline, saline plus adrenalin, saline plus anterior pituitary-like hormone, human pregnancy urines, frog blood serum, frog lymph, or fluids sometimes found in the body cavity of the frog, there was no increase in the volume of the testes as determined by measurements and no emission of spermatozoa. When the testes were placed in distilled water plus adrenalin, distilled water plus A.P.L., distilled water alone, or frog urine, all testes increased in volume as determined by measurements and emitted spermatozoa.

Since the emission of spermatozoa is correlated with an increased testis volume as well as the presence of hypotonic solution it appears that this strengthens the hypothesis made earlier that the release of spermatozoa is due to the diffusion of a hypotonic solution into testicular tissue. It appears that the diffusion of the hypotonic solution into testicular tissues may be the cause of the increased size. It also indicates that the emission of spermatozoa can be explained without the assumption of smooth muscles in the testes, for if smooth muscles alone were involved there would be a decrease in the size of the testis in at least one dimension.

TABLE 3

Summary of the effects of subcutaneous injections on the size of the testes and the emission of spermatozoa into the urine.

Substance Injected	Testes Measured	Testes Increasing in Size	Testes Not Increasing in Size	Frogs With Sperm in their Urine	Frogs With out Sperm in Urine
2 cc. 100 I.U. A.P.L. in Dist. Water	24	22	2	11	1
2 to 4 cc. of Dist. Water	20	0	20	0	10
10 cc. of Dist. Water	20	20	0	10	0
10 cc. of Saline	20	0	20	0	10
4 cc. of Raw Pregnancy Urine	20	18	2	9	1
4 cc. of non-Pregnancy Urine	20	0	20	0	10

These conclusions suggest that a similar pressure action by hypotonic fluids might be associated with the emission of spermatozoa from intact testes. If this were the case one would expect an increased size of testes in frogs which release their spermatozoa following injections of gonadotropins. In order to determine this the next series of experiments was undertaken.

The relation of the volume of testes in situ to the emission of spermatozoa. Testes in situ were measured preceeding and following subcutaneous injections of (a) 100 I.U. of anterior pituitary-like hormones in 2 cc. of distilled water, (b) 4 cc. of human pregnancy urine, and (c) 10 cc. of distilled water. These testes increased in volume and emitted spermatozoa. The increases averaged 0.4 mm. in length and 0.15 mm. in width or depth. Similar measurements were made on testes in situ of frogs receiving subcutaneous injections of (a) 2 cc. of distilled water, (b) 4 cc. of non-pregnancy urine and (c) 10 cc. of saline. These testes did not increase in volume as determined by measurements nor did they emit spermatozoa. This experiment is summarized in table 3. The increase in volume is therefore

associated with an emission of spermatozoa in intact testes. The increased volume can be explained on the basis of an increased diffusion pressure resulting from the entrance of a hypotonic fluid into the testis. In this experiment the frogs which were injected with substances associated with a release of spermatozoa were the only ones whose testes increased in size. Therefore, these substances, anterior pituitary-like hormones, human pregnancy urines, and water in 10 cc. amounts, are believed to act on the structure of the urogenital system in such a manner that a hypotonic fluid is introduced into the testes.

Observations on the urogenital system of injected frogs. Observations were made on the urogenital system of frogs which had received a subcutaneous injection of 100 I.U. of anterior pituitary-like hormones or 3 cc. of raw human pregnancy urine. When the frogs received these injections, the glomeruli and Bowman's capsules swelled and became visible through the surface of the kidney. This was associated with an increase in testis volume as well as an emission of spermatozoa. However, when similar observations were made on frogs which received an injection

TABLE 4

The effect of neural extirpations on the release of spermatozoa

Part of Brain Extirpated	Approx. No. of Trials	Injection Solution	No. Time Spermatozoa were Recovered in Urine
Entire brain	65	A.P.L. or H.P.U.	0
Midbrain	40	A.P.L. or H.P.U.	0
Optic lobes only	70	A.P.L. or H.P.U.	0
Transection posterior to optic lobes	20	A.P.L. or H.P.U.	0
Transection of spinal cord to posterior to medulla	30	A.P.L. or H.P.U.	0
Forebrain	60	A.P.L. or H.P.U.	60
Cerebellum only	10	A.P.L. or H.P.U.	10
Pituitary only	20	A.P.L. or H.P.U.	20
Transection anterior to optic lobes	45	A.P.L. or H.P.U.	45

of either 2 cc. of water or non-pregnancy urine, there were no swellings in either the glomeruli or the capsules, nor did these testes increase in size or release their spermatozoa.

Richards *et al.* (1927), determined that the addition of adrenalin in certain titers resulted in a swelling of the glomeruli. This was due to the constricting action of adrenalin on the efferent vessel of the glomerulus. Since the leopard frog responds to adrenergic substances, human pregnancy urine and anterior pituitary-like hormone, by releasing spermatozoa and the glomeruli swells when these substances are applied it may be possible that the action of anterior pituitary-like hormones and human pregnancy urines may also cause the constriction of the efferent vessel of the glomerulus increasing the pressure in the urogenital circulation.

Experiments with brain extirpations. The effect of various brain operations on the emission of spermatozoa from the testes to the bladder were studied. When

the olfactory lobes, cerebral hemispheres, pituitary and cerebellum were extirpated there was an emission of spermatozoa following the injection of gonadotropins. However, when the entire mid-brain or the optic lobes alone were extirpated there was no emission of spermatozoa. Therefore, it was concluded that the optic lobes exerted a neutral control on the urogenital system. In the light of the evidence of the stimulating effect of hypotonic solutions on the emission of spermatozoa it appears that the influence of gonadotropins is exerted on the kidney. If this were the case the destruction of the optic lobes may destroy or inhibit the muscular tone of the vascular system of the kidney. The results of this experiment are summarized in table 4.

It is believed that this view is supported by the results of an experiment on the effects of subcutaneous injections of water on frogs with pithed and extirpated optic lobes. Table 5 is a summary of this experiment which indicates that 10 cc. amounts of distilled water stimulates the emission of spermatozoa even though

TABLE 5

The effect of 10 cc. of saline and 10 cc. of water on the emission of spermatozoa in frogs with either optic lobe extirpations or pithed brains.

Part of Brain	Number of Trials	Injected Solution	Number Times Spermatozoa Were Recovered in Urine
Entire brain, pithed	10	10 cc. water	10
Optic lobes only extirpated	5	10 cc. water	5
Entire brain pithed	10	10 cc. saline	0
Optic lobes only extirpated	5	10 cc. saline	0

the neural associations have been destroyed. This would indicate that either water has a greater affect on the muscles of the kidney than anterior pituitary-like substances and human pregnancy urine or that it is available to the testes through dilution of the blood and increase in vascular pressure even though the optic lobes were destroyed.

CONCLUSIONS

From the results of the experimentations on excised testes, intact testes, and injections following brain extirpations the following conclusions appear to be justified:

1. Hypotonic fluids are associated with the release of spermatozoa from the testis.
2. An increase in the volume of the testis is associated with the movement of spermatozoa from the testis to the urine.
3. Gonadotropic substances are not associated directly with the emission of spermatozoa from the testis.
4. The association of an increase in testis size with the emission of spermatozoa seems to indicate the presence of a diffusion pressure within the testis.
5. There is visible evidence that seems to indicate that gonadotropic substances directly affect the vascular system of the kidney when spermatozoa are emitted.
6. In the normal frog the release of spermatozoa, following the injection of gonadotropic substances, is influenced by the optic lobes because the extirpation of the lobes destroys the release mechanism.

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An Introduction to the Study of Insects. *Donald J. Borror* and *Dwight M. DeLong.* Rinehart and Company, New York. 1954. ix + 1030 pp. $9.00.

This book, the work of two outstanding teachers and scholars, can be used either in a general course or in a course on the identification of adult insects. The information on collecting and the keys will be useful to the professional worker.

The bulk of the book is occupied by chapters on the various orders. Each of these chapters has a short introduction, then a key to the families followed by a discussion of the appearance and the biology of the families covered in the key, and ends with suggestions for collecting and preserving the members of the order under consideration. The introductory chapters briefly cover anatomy and development, and contain an unusually complete discussion of nomenclature. The concluding chapters discuss other arthropods, insects in relation to man, and control. In addition, there is a very complete chapter on collecting and preserving. The final chapter on insect study activities and projects is a novel and welcome addition to a college science textbook.

This book is especially noteworthy for its excellent keys to the adults of insect families. These keys use the newest accepted names and are comprehensive and workable. Only exceptionally rare or minute families are omitted. Keys to the subfamilies of some of the larger groups are provided. Many key characters are illustrated within the key near the couplet where they are introduced. The large print, especially in the keys; the fine selection of line drawings, many original; and the large glossary are other features making this book a welcome addition to entomological texts.

HOWARD W. HINTZ.

NEW OHIO RHYNCHOPHORA. I. (*COLEOPTERA, CURCULIONIDAE*)

ELBERT L. SLEEPER

Department of Zoology and Entomology, The Ohio State University, Columbus 10

During the preparation of a bulletin on the Rhynchophora, except Scolytidae, of Ohio, numerous new forms have been discovered. This is the first of several papers devoted exclusively to Ohio Rhynchophora new to science. It might be stated here that many of the following species were collected in areas that are small relic communities with an ecology very different from that of the surrounding area.

Phyllotrox fulvipennis n. sp.

Figures 6 and 9

Female.—Elongate; reddish brown with head, an area around scutellum, and mesosternum darker, the elytra brownish yellow; thinly clothed with very fine yellow pubescence, mesosternum densely clothed with white pubescence.

Rostrum two-thirds as long as pronotum, cylindrical, closely and finely punctured, smoother at apex; sparsely clothed with fine recumbent yellow setae. Antennae inserted just beyond middle; scape feebly arcuate, not attaining eyes; first segment of funicle stout, twice as long as second, the second one-half longer than third, remainder subequal in length, gradually wider toward club. Club round, densely clothed with fine white pubescence. Head convex; closely, finely punctured; not foveate between eyes. Eyes black and strongly convex.

Prothorax flattened; as wide as long; sides feebly, evenly rounded, feebly constricted at apex; closely, coarsely, very shallowly punctured; intervals between punctures alutaceous, each puncture with a recumbent yellow seta. Scutellum triangular, broad, feebly convex; minutely punctured.

Elytra elongate; wider than pronotum; sides feebly arcuate, broadest at middle; humeri rounded; clothed with fine, recumbent, yellow setae; striae feebly impressed, punctures close-set, small deep, rectangular; intervals flat, with confusedly placed, minute, very shallow punctures.

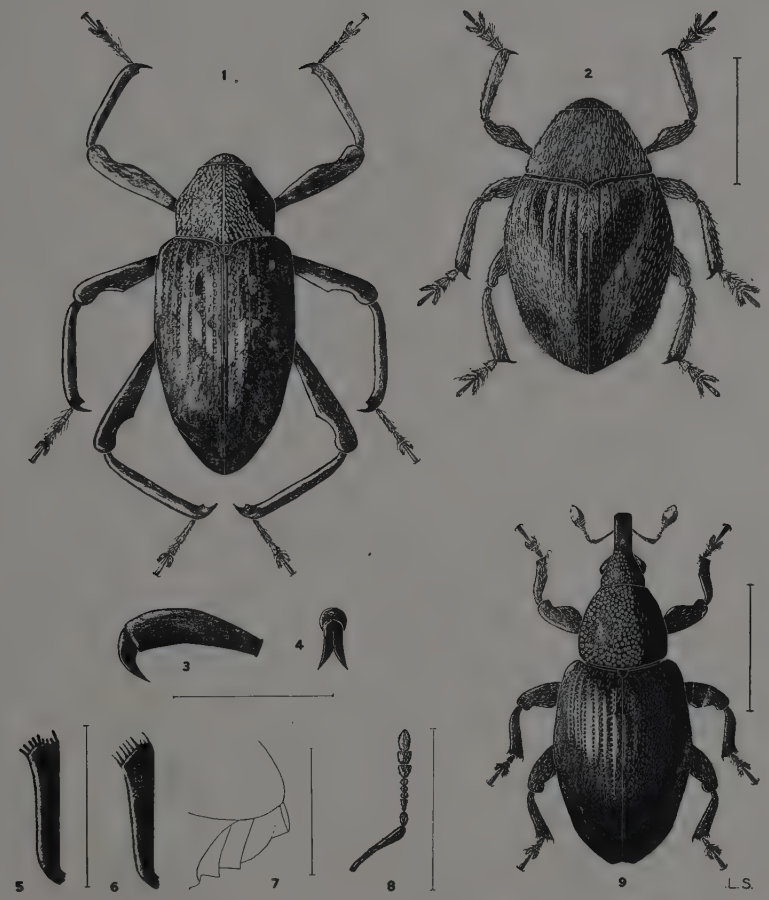
Ventral side convex. Prosternum short before coxae; metasternum finely, sparsely punctate, white pubescence recumbent. Abdominal segments 1, 2, and 5 subequal in length; fifth as long as three and four combined; 1–4 with sparse, fine, shallow punctures, fifth more coarsely and closely punctured. Legs stout, sparsely clothed with very fine yellow setae. Femora very robust, unarmed. Anterior tibiae narrower than others with a dense patch of pubescence mesally at apex. Middle and posterior tibiae stout, widening toward apex, obliquely truncate at apex, the apex with long, narrow, sharp spines. Third tarsal segment broadly bilobed. Claws simple, divergent. Pygidium flat.

Length 2.1 mm., width 1.0 mm.

Male.—Pygidium slightly convex with a broad, deep, median longitudinal groove; anterior tibiae not obliquely truncate. Length 2.0 mm., width 1.0 mm.

Type material.—Holotype, ♀, Crane Hollow, Hocking County, Ohio, V-27-50, NJ &ELS.* Allotype, ♂, Hocking County, Ohio, IV 29-50, NJ & ELS, in (ELS). There are 166 paratypes deposited as follows: in (ELS), 70 ♂, 75 ♀, Hocking County, Ohio, IV-29-50, NJ & ELS, 1 ♂, 3 ♀, Hocking County, Ohio, V-27-50, NJ & ELS; in the United States National Museum, 3 ♂, 3 ♀, Hocking County, Ohio, IV-29-50, NJ & ELS; in the Entomological Collection, Ohio University, Athens, 6 ♂, 5 ♀, Rock Run, Jackson County, Ohio, V-11-35, W. C. Stehr. Material is also at hand from Ashland and Greene Counties, Ohio, but is not a part of the type series.

*The abbreviations NJ & ELS and (ELS) refer to N. J. & E. L. Sleeper and the author's collection respectively.



1. *Sternochetus woodruffi* n. sp., holotype, ♂.
2. *Nanophyes confusor* n. sp., holotype, ♂.
3. Lateral view of last tarsal segment and claws of *Nanophyes confusor* n. sp., holotype, ♂
4. Connate claws of *Nanophyes confusor* n. sp., holotype, ♂.
5. Posterior tibiae of *Phyllotrox nubifer* LeConte, ♀.
6. Posterior tibiae of *Phyllotrox fulvipennis* n. sp., holotype, ♀.
7. Lateral outline of abdominal segments 3, 4 and 5 of *Acanthoscelidius isolatus* n. sp., holotype, ♀.
8. Antennae of *Nanophyes confusor* n. sp., holotype, ♂.
9. *Phyllotrox fulvipennis* n. sp., holotype, ♀.

Figures 1–2, 7–9. Line = 1 mm.
Figures 5–6. Line = ½ mm.
Figures 3–4. Line = ¼ mm.

This species is very similar in general appearance to *P. nubifer* LeConte. It differs in having the punctures of the pronotum finer, punctures of rostrum finer laterally, more shallow, punctures between eyes finer, irregular, not as coarse and deep as in *nubifer*, punctures of elytral intervals much finer. The distal end of the posterior tibiae of *flavipennis* has long narrow sharp spines, while that of *nubifer* has spines that are short, robust and more blunt.

Magdalis hockingensis n. sp.

Male.—Elongate, wedge-shaped; black, feebly shining; without vestiture except for very short white seta-like scales on legs.

Rostrum longer than pronotum, strongly curved, coarsely and densely punctured basally, punctures finer in apical half. Antennae inserted in basal third; first segment of funicle stouter, as long as second. Head strongly alutaceous, sparsely and coarsely punctured.

Prothorax slightly longer than wide, sides straight, feebly constricted at apex, hind angles feebly produced, scarcely divergent; pronotum without trace of smooth median line, densely moderately punctured, the intervals between punctures alutaceous. Scutellum quadrate, sloping forward.

Elytra at base scarcely wider than prothorax, sides straight, strongly convergent from base to apical fourth then strongly rounded to apex; striae noticeably impressed, strial punctures deep, rectangular, nearly contiguous; intervals nearly flat, strongly alutaceous, each with a row of punctures at least as wide as the intervals.

Ventral side with abdominal segments finely punctured, sparsely at sides, more densely at middle. Femora unarmed, front femora obliquely impressed at base. Claws simple.

Length 2.7 mm., width 1.1 mm.

Female.—Unknown.

Type material.—Holotype, ♂, Crane Hollow, Hocking County, Ohio, V–27–50, NJ & ELS, 1 ♂, paratype, same locality as holotype, V–1–54, ELS, both in (ELS).

This species is nearest to *M. hispoides* LeConte, from which it differs in having the prothorax with the sides more cylindrical, pronotum flatter, more finely punctured; elytra with sides more strongly divergent, striae more deeply impressed; ventral side more sparsely finely punctured. This weevil was beaten from an oak but it undoubtedly breeds in pine as do most of the other members of this group. There were sizeable stands of pine nearby. The paratype was beaten from Scotch pine.

Nanophyes confusor n. sp.

Figures 2, 3, 4, and 8

Male.—Oval, convex, robust; reddish brown, with the head, rostrum, apical margin of prothorax, an oblique bar and a lateral subapical spot, the thoracic sterna, and all but the fifth abdominal segment black; densely clothed dorsally with narrow, flat, recumbent, pale yellow scale-like setae, the black fascia of elytra with very fine recumbent black setae.

Rostrum slightly longer than the pronotum; cylindrical, the dorsal line feebly arcuate when viewed laterally, ventral line straight; broadly bisulcate laterally; a strong median and two prominent lateral carinae in basal half; very sparsely clothed with pale yellow setae. Antennae inserted just beyond middle. Scape attaining the eyes, funicle 5-segmented; first segment elongate, robust, second segment elongate and more slender than the first, remaining segments short, rounded, subequal. Club elongate, very loose, last segment as long as preceding two. Head conical, alutaceous, very sparsely and finely punctured; vertex with a very short prominent carina. Eyes narrowly separated above, feebly convex, strongly granulate.

Prothorax conical, sides strongly convergent to apex which is about one-half width of base; pronotum strongly alutaceous, finely sparsely punctured. Scutellum not visible.

Elytra oval-robust, base slightly wider than base of prothorax; sides strongly arcuate to apical fourth then convergent to apex; humeri obsolete; striae deeply impressed, strial punctures strong, separated by twice their diameter; intervals very broad, strongly convex, densely and confusedly punctured; vestiture denser on basal fourth of second interval.

Ventral side sparsely clothed with finer vestiture; strongly alutaceous. First, second, and fifth segments, subequal, much longer than third and fourth combined; fifth broadly truncate.

Pygidium very prominent from ventral aspect, appearing as a sixth abdominal segment. Legs robust, sparsely clothed with fine pale setae. Femora unarmed. Claws connate to middle, very feebly divergent.

Length 2.25 mm., width 1.25 mm.

Female.—Rostrum one-fourth longer than pronotum, apical fourth dark reddish brown. Fifth abdominal segment feebly truncate at apex; nearly as long as first and second segment behind posterior coxae. Length 2.3 mm., width 1.3 mm.

Type material.—Holotype, ♂, allotype ♀, from Cranberry Bog, Buckeye Lake, Licking County, Ohio, VI–18–50, NJ & ELS, in (ELS). Eighty-eight paratypes as follows: in (ELS), 34 ♂, 35 ♀, same data as holotype, 1 ♂, 1 ♀, Buckeye Lake (Collected at Cranberry Bog), Ohio, VII–9–46, J. A. Wilcox; in the Canadian National Collection, 8 (sex undetermined) same data as holotype; 4 ♂, 5 ♀, Buckeye Lake, Licking County, Ohio, VI–20–53, R. E. Woodruff, in collection of the collector.

This has been compared with the holotype of the only other species of the genus known from North America, *Nanophyes canadensis* Brown by the author of that species and is quite unlike it. *N. confusor* seems to be nearest *marmoratus* (Goeze) (*lythri* Fab.) from Southern Europe. *N. confusor* is more robust, more densely pubescent, and has the antennal club and base of the elytra pale reddish brown. The pronotum and abdominal segments are alutaceous.

Previously this has been sent to some workers under the name *Corimalia pallidulus* ?? (Gozis) but it is a *Nanophyes* and not a *Corimalia* as the latter has a compact antennal club and free tarsal claws.

Acanthoscelidius isolatus n. sp.

Figure 7

Female.—Broad, oval, robust; black, the funicle and club with a reddish tinge; sparsely clothed with brown and white, flat, clavate, prostrate scales; a patch of white scales condensed around the scutellum on elytra.

Rostrum five-sixths as long as pronotum, subcylindrical; viewed dorsally it is widened from base to middle, then narrowed again to apex; a prominent median keel-like carina from point of insertion of antennae to apical margin of prothorax; deeply, coarsely, rugosely punctured throughout. Antennal funicle 7-segmented; first segment short and robust, second segment very slender, nearly twice as long as third and fourth combined, third and fourth subequal, remaining segments short and rounded. Club compact, oval, and densely pubescent. Head very coarsely, closely, deeply punctured. Eyes very feebly convex, finely granulate.

Prothorax one-third wider than long, sides strongly rounded to a strong apical constriction; pronotum coarsely and deeply punctured with punctures of irregular size, the bottom of each puncture strongly alutaceous; two small pointed tubercles present laterally, a median dorsal channel distinct in basal third. Scutellum very long and narrow, about five times longer than wide.

Elytra one-half wider at base than prothorax, as long as wide; sides strongly rounded from humeri; striae deep, with round, deep, distant punctures; intervals wider than striae, convex, intervals 3, 5 and 7 strongly elevated, wider than other intervals, all intervals with very prominent asperites which bear brown recurved scales.

Ventral side coarsely and densely punctured throughout. Apical third of first and all the second abdominal segment concave at middle; fifth segment when viewed in profile strongly arched upward to a flat apical area (fig. 7). All segments clothed with broad, flat, white scales. Legs robust, clothed with scales as on dorsum; middle and posterior tibiae with dense, long, brown pubescence along outer apical margin. Femora unarmed, grooved beneath receiving tibiae. Anterior tibiae slender, outer apical angle prolonged in a toothed process; middle and hind tibiae toothed on outer edge at one-third from apex. Claws with a long slender tooth.

Length 3.1 mm., width 2.0 mm.

Male.—Unknown.

Type material.—Holotype, ♀, Hocking County, Ohio, VII–12–50, NJ & ELS, in (ELS). The type was found in a rather isolated hollow along Clear Creek.

This weevil is unlike any other of the genus. It resembles *Auleutes tenuipes* (LeConte) but may be separated from it by the prolongation of the anterior tibiae. The peculiar modification of the fifth abdominal segment and the very deeply, coarsely punctured pronotum separates *isolatus* from the other members of *Acanthoscelidius*. It seems to represent an intermediate form between the genera *Acanthoscelidius* and *Auleutes*. Further study may make it necessary to combine these genera.

Auleutes triplehorni n. sp.

Male.—Broadly oval; shining, black with the funicle dark reddish black; clothed with broad, flat, white scales and moderately long, black, brown, and white setae; the broad white scales are arranged in patterns on pronotum and a cruciform spot on elytra, the setae on elytra are arranged in rows on intervals.

Rostrum one-third longer than pronotum, coarsely, deeply and densely punctured in basal three-fourths, apical fourth smooth and nearly impunctate; no evidence of a median carina. Antennae inserted just behind middle. Funicle 6-segmented, first segment elongate and robust, second and third elongate slender and subequal, the remainder short, one-half length of third. Club elongate, not distinctly annulated, densely clothed with long fine pubescence. Head coarsely, deeply, densely punctured, many punctures coalescent, forming strigae; a prominent carina from vertex to apical margin of pronotum; front with a patch of white scales. Eyes feebly convex, upper margin elevated above the level of front.

Prothorax one-fourth wider than long; sides strongly rounded to a strong apical constriction, apical margin reddish brown; pronotum coarsely, deeply, densely punctured with punctures of irregular size; lateral tubercles prominent; base of pronotum with a very prominent median lobe which cuts off the scutellum. Scutellum very small and round.

Elytra more than one-half wider at base and prothorax, as wide as long; sides strongly rounded to apex; striae deeply impressed, strial punctures shallow, elongate and distant; intervals wider than striae, strongly elevated, each with a row of moderate asperites, each of which bears a recurved setae.

Ventral side coarsely and moderately punctured, punctures of abdominal segments coarser, deeper, each bearing a broad, flat, white scale. First abdominal segment broadly and shallowly impressed. Fifth segment a little longer than the fourth, with a small deep pit densely filled with brownish yellow, erect, broad, flat scales. Legs sparsely clothed with narrow brown and white setae which are denser at apex of tibiae. Femora unarmed, grooved beneath. Anterior tibiae not prolonged outward at apex. Claws long and divergent, with a short tooth.

Length 2.0 mm., width 1.3 mm.

Female.—Differs from the male in that the first abdominal is not impressed and the fifth is as long as the third and fourth combined. Length 2.0 mm., width 1.3 mm.

Type material.—Holotype, ♂, and allotype, Clear Creek, Goodhope Twp., Hocking Co., Ohio, IV–25–54, NJ & ELS, in (ELS). Eight paratypes as follows: 1 ♂, same data as holotype; from the same locality and with same collectors, 1 ♂ V–1–54, 1 ♀ V–12–54, 1 ♀ V–27–50, 1 ♀ V–29–51, 1 ♀ Ross Co., (Tar Hollow), V–22–51, C. A. Triplehorn, 2 ♂ Hamilton Co., V–18 and VI–10, all in (ELS). All examples were swept from plants on wet ground.

A. triplehorni will key in Blatchley & Leng (1916) to *A. marionis* Fall because of the 6-segmented funicle, but they are very different otherwise. *A. triplehorni* may be separated easily by the black color and the prominent fovea on the last abdominal segment of the male.

Tyloderma asclepiasae n. sp.

Female.—Elongate, robust, strongly convex; bluish black, with the antennae, tibiae, and tarsi reddish brown; without a trace of vestiture.

Rostrum slightly more than half as long as pronotum and slightly curved; coarsely, densely and rugosely punctured throughout. Head strongly alutaceous, finely, deeply, and sparsely punctured; a deep elongate fovea from vertex to middle of the front.

Prothorax slightly wider than long, sides parallel in basal two-thirds, then strongly constricted to apex; pronotum finely alutaceous becoming stronger basally, coarsely and sparsely

punctured; sides of prothorax strongly alutaceous, coarsely and deeply punctured. Scutellum very small, round and alutaceous.

Elytra behind oblique humeri, more than one-third wider than prothorax, sides rounded, widest about one-third from base; strongly alutaceous; striae absent, strial punctures very feeble, only those of first striae prominent in basal third; intervals each with a row of minute punctures in basal half, punctures of striae and intervals obsolete laterally and apically.

Ventral side with metasternum strongly alutaceous, coarsely and deeply punctured, each puncture with a minute flat, broad, white scale. All abdominal segments strongly alutaceous, first and second abdominal segments fused, the suture obsolete, both impunctate, second segment with two shallow pits; third and fourth subequal, alutaceous, impunctate; fifth abdominal segment deeply and coarsely punctured but without other modification, evenly rounded apically. Legs strongly alutaceous, coarsely and sparsely punctured, sparsely clothed with scales as on metasternum. Claws small, divergent, simple.

Length 3.2 mm., width 1.5 mm.

Male.—Unknown.

Type material.—Holotype ♀, Ohio State University Woods, Franklin County, Ohio, VI-7-50, NJ & ELS, in (ELS). Swept from *Asclepias incarnata* L., the stem of which bore oviposition scars typical of most species of *Tyloderma*.

This species is nearest *T. nigra* Casey, but *asclepiasae* has the punctures of the pronotum and the sides of prothorax sparser, the first four abdominal segments of *nigra* are finely strongly and distantly punctured, while in *asclapiasae* they are impunctate. The latter differs from *T. aera* (Say) by the coarser punctures of the pronotum and lateral areas of the prothorax; *aera* has the first four abdominal segments minutely punctured, and the first segment coarsely punctured between metacoxae.

Many authors have considered *T. nigra* Casey as a variety of *T. aera* (Say). However, a study of the characters given by Blatchley (1916, p. 490, 493), of a large series of both forms, along with their biologies, prove them to be two distinct species.

Sternochetus woodruffi n. sp.

Figure 1

Male.—Elongate-oval, robust; dark reddish black with the antennae and tarsi reddish brown; densely clothed with brown, white, and black, broad, flat, prostrate scales which are much larger on pronotum; a prominent crest of black scales at basal fourth of third elytral interval.

Rostrum one-fourth longer than pronotum, strongly arcuate, deeply, coarsely and rugosely punctured in basal two-thirds, smooth, shining, and finely punctured in apical third; a prominent median carina in basal half, faint indication of lateral carinae. Antennae inserted at apical third. Funicle 7-segmented; first segment short and robust, second slender and almost one-half longer than first, third and fourth subequal, three-fourths as long as second, remaining segments subequal, rounded. Club elongate, not distinctly annulated. Head coarsely and deeply punctured, a faint carina in evidence at vertex, above each eye a short blunt tubercle, front concave, rugosely punctured, with a small, deep, rounded fovea.

Prothorax wider than long, sides subparallel in basal half, then strongly convergent to apex which is not visibly constricted; a median carina present, strongly elevated at middle; pronotum coarsely, deeply and densely punctured, each puncture with a broad, flat, clavate scale, the black scales nearly erect, more robust and narrower than others. Scutellum small, round, strongly convex, shining and denuded.

Elytra elongate, much wider at base than prothorax, sides parallel in basal half, then convergent to apex; humeri prominent, rounded; striae impressed, punctures large, quadrate and moderately deep, each puncture with a long narrow flat scale; intervals broad, odd intervals feebly convex, even intervals flat, punctures of intervals fine and very closely placed.

Ventral side with abdominal segments coarsely, deeply, and densely punctured, each puncture with a very short broad scale; second, third, and fourth abdominal segments subequal; first segment feebly concave at middle, fifth subequal to first, feebly concave at middle. Legs long and slender. All femora with a very minute denticle. Tibiae coarsely punctured, anterior edge longitudinally strigose.

Length 7.5 mm., width 3.2 mm.

Female.—Very similar to male; rostrum rugosely punctured in basal half, median carina prominent, lateral carinae not in evidence; head without carina or tubercles, front not concave; first and fifth abdominal segments not concave; fifth coarsely and evenly punctured, posterior margin deflexed sharply downward. Legs shorter, more robust. Length 7.8 mm., width 3.5 mm.

Type material.—Holotype, ♂, and allotype, ♀, Cranberry Bog, Buckeye Lake, Licking County, Ohio, VI–20–53, R. E. Woodruff. Holotype in (ELS), allotype in collection of R. E. Woodruff.

This is nearest *S. helvus* (LeConte) which it resembles superficially, but may be easily separated by the structure of the funicle and the presence of the black crest of scales. The females of *helvus* on hand have a smooth triangular impunctate area on the anterior margin of the fifth abdominal segment. All examples of *helvus* that the author has seen were from Florida.

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Careers and Opportunities in Science. *Phillip Pollack.* E. P. Dutton and Co., Inc., New York, 1954. 252 pp. $3.75.

The reading of this little book by our high school students should be very helpful in making their decision on a career in Science. The infectious enthusiasm of the author and his convincing style make this book an excellent addition to the already existing guides for professional careers. The author properly emphasizes the importance of thorough training for those who wish to attain success in their undertakings, and for this purpose a list of institutions for training in special fields is provided. The present great demand for scientists and the multitudes of opportunities open to young men and women are the chief topics of the first chapter. Subsequent chapters deal with the nature of research problems in fifteen specific fields and give inspiring descriptions of work accomplished in recent years. A special chapter is devoted to science careers for women and provides many illustrations of the valuable contributions made by them in all fields of endeavor. In the appendix salary ranges for science careers are tabulated, but all through his book the author emphasizes the great spiritual rewards coming to those who have chosen to devote their lives to solve the problems of science.

NICHOLAS MOGENDORFF.

Acoustics. *Leo L. Beranek.* McGraw-Hill Book Company, Inc., New York. 1954. x+ 481 pp. $9.00.

Of the several textbooks on acoustics which have appeared since the War this is undoubtedly the most ambitious. Professor Beranek, already justly famous in this field for his book entitled "Acoustic Measurements" (John Wiley, New York, 1949) has written a sophisticated introduction to acoustics for the serious student who is already familiar with mathematics through college courses in differential equations, complex variables and elementary matrices. The book throughout emphasizes the practical aspects of the subject. The author warns the reader in the preface that ". . ., the engineer or scientist who wishes to practice in the field of acoustics and who does not intend to confine his efforts to theoretical matters must know the material of this text." Not only are such fundamental principles as the wave equation and the concept of acoustic impedance thoroughly treated, but detailed applications are made to acoustic systems such as loudspeaker enclosures (simple and bass-reflex), horns, microphones and rooms. Examples, with solutions, are interspersed in the text and an adequate collection of problems, correlated with the various chapters, is given at the back of the book. In the reviewer's opinion, the author has succeeded in writing a definitive text. It should find wide acceptance in colleges and universities for senior and graduate courses in acoustics.

C. H. SHAW.

TWO NEW OHIO LOCALITIES FOR THE RED-BELLIED WATER SNAKE

ROGER CONANT

Zoological Society of Philadelphia, Philadelphia 4, Pennsylvania

Until recent years thriving colonies of *Natrix erythrogaster neglecta* existed in Hardin County near Mt. Victory and in Williams County near Blakeslee. These were the only known stations in Ohio for this snake (Conant, 1934, 1938). Drainage and agricultural activities have now so altered both localities, however, that it is a fair assumption they no longer are inhabited by *neglecta*, which is a northern relict race of a species that ranges widely through the southern states and into northern Mexico.

It is heartening, therefore, to report two new localities for this rather rare water snake, both in Williams County and both made known through the energies of O. E. Ehrhart, amateur naturalist of Antwerp, Ohio. Mr. Ehrhart has very kindly sent me three specimens (two of them alive) for my examination, together with notes and photographs of the habitat. I am also indebted to Dr. Edward S. Thomas, of the Ohio State Museum, who has visited both areas and who has supplied descriptions of them as quoted below. The two new localities are:

I—Mud Lake, in the northern portion of Secs. 33 & 34, Northwest Township, Williams County, Ohio.

Mr. Ehrhart first encountered the "copperbelly" in this locality on June 27, 1951, when he collected one specimen, and observed another which eluded him. Taken at the same time were two ribbon snakes, *Thamnophis sauritus sauritus*, and a common water snake, *Natrix sipedon sipedon*. All were at the edge of the water. On May 31, 1953, Ehrhart saw, but did not obtain, two additional "red-bellies." He caught one on September 7, 1953. This and the original specimen are preserved in his private collection.

Mud Lake "is a glacial kettle lake surrounded by a rather extensive boreal relict bog-meadow. From the absence of sphagnum and cranberry and the presence of shrubby cinquefoil, *Spirea alba*, and Kalm's lobelia, one may conclude that it is an alkaline or 'marl' bog rather than an acid one. Among the conspicuous boreal relict plants, in addition to those mentioned, are: swamp thistle, tamarack (a few only), poison sumac, marsh fern, and red-osier dogwood." (Thomas, in *litt.*)

II—Florence Township, Williams County, Ohio.

This locality is in the northwest portion of section 6, Florence Township, about one-half mile east of the Indiana line and approximately two miles south of U. S. highway 20. Ehrhart collected two specimens of *neglecta* there on May 3, 1953, and he has presented both to the Ohio State Museum (OSM 976, 979).

This locality was described on September 13, 1953, by Thomas (in *litt.*) as follows: "A marshy swale in the Wabash Moraine, about ten acres in area. Swamp forest of about equal area on opposite (north) side of road. The marsh consisted largely of herbaceous vegetation, but there were many scattered shrubs of *Cornus obliqua*, *Spirea alba*, Buttonbush (*Cephalanthus occidentalis*), and saplings of soft maple. There were large areas covered with a mixture of cut-grass and arrow-leaf tear-thumb, much of it waist high, which made tough going. Sizable colonies of *Aster puniceus*, *Boehmeria cylindrica*, Wool-grass, *Carex lacustris* (?), *Solidago altissima* (*canadensis* ?), and fragrant goldenrod. Other conspicuous plants:

Sensitive fern, *Iris* sp., cattail, *Eupatorium maculatum*, *Calamagrostis*, *Scutellaria lateriflorus*, cardinal flower and *Persicaria Muhlenbergia* (along road)."

At the time the two snakes were collected the marsh was filled with standing water, but none was present when the locality was revisited by Ehrhart on July 26, and by Thomas on September 13, 1953. Hence, in this respect, the habitat is similar to those formerly existing near Mt. Victory and Blakeslee where *neglecta* was encountered in the water in the spring but was found as much as 200 yards from the ponds during mid-summer. Apparently, *neglecta* is able to tolerate considerable desiccation of its habitat, becoming terrestrial in warm weather and seeking its food (largely frogs?) by wandering well away from the shallow ponds or swales that are concentration points in the spring.

The much more widely distributed and common water snake, *Natrix s. sipedon*, is rather closely restricted to streams and other permanent bodies of water. It was a rarity at Mt. Victory and Blakeslee, and has not as yet been reported from the Florence Township locality.

The relative abundance of *neglecta* and *sipedon* at Mud Lake is unknown, but the surrounding boreal relict bog may serve as a suitable habitat for *neglecta* whereas the more aquatic *sipedon* may be more closely restricted to the perimeter of the Lake.

The only other locality for *neglecta* with which I am familiar is at Olivet, Michigan. Here Clark (1903) found *erythrogaster* (=*neglecta*) abundant in a tract of low land bordering a creek which connects Pine Lake with the Olivet mill pond. Within this tract *sipedon* was not often encountered. Elsewhere in the general vicinity *sipedon* was extremely common (according to Clark) and the "copperbelly" was not found at all.

From the limited evidence at hand it would appear that these two rather similar water snakes may occupy almost mutually exclusive habitats, at least in Ohio and possibly also in Michigan: (1) *neglecta*, a relict, occurs in scattered colonies in areas not readily tolerated by *sipedon;* and (2) *sipedon* is wide-ranging and most abundant near permanent bodies of water. Once its habitat is destroyed, *neglecta* disappears, whereas *sipedon* conceivably could move to any nearby stream or pond and find a suitable environment.

The three specimens of *neglecta* which I have examined (two from Florence Township and one from Mud Lake) are all males and all are typically colored—uniform very dark brown or very dark grey above and bright orange red below. Considerable dark pigmentation from the dorsum invades the antero-lateral portions of the ventrals. All three have maxima of 23 rows of scales. In the specimen from Mud Lake the ventral count is 150; in the other two the counts are 145 and 147, the lowest recorded for any Ohio snakes of the species.

Robert Kavanagh, of Columbus, reports having killed six or more red-bellied "black" snakes in former years in Washington Township, Union County, about one-half mile from the Logan County line and about two miles south of the Hardin County line. This would place the locality approximately four miles south of Mt. Victory. He has not seen one in this area for twenty years, however; the habitat has probably been destroyed. Other localities where *neglecta* may have formerly occurred were reviewed recently (Conant, 1951, p. 229). Other reports on past or present distribution of *Natrix erythrogaster neglecta* in Ohio or elsewhere would be appreciated.

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CONTROL OF SPITTLEBUGS ON STRAWBERRIES

E. P. BREAKEY

Western Washington Experiment Station, Puyallup

Large numbers of spittlebug nymphs, *Philaenus leucopthalmus* (L.) were found infesting strawberry plants on May 5, 1953, near Winlock, Washington. Most of the nymphs were so young they had not yet formed spittle masses. The field had been planted in 1952. Leaves of the mother plants were badly twisted and distorted and the petioles greatly shortened, while the leaves of the runner plants apparently were developing normally. Apparently eggs had been laid on the mother plants late in the summer of 1952 before the formation of the runner plants and the very young nymphs had not yet dispersed.

Arrangements were made to apply insecticide dusts with as little delay as possible. Early applications of insecticide dusts on a crop such as strawberries would be highly desirable since there would be a minimum danger of leaving a poisonous residue on the fruit. Rosenstiel (1951) advises dusting as soon as possible after the fruit spurs separate in the blossom clusters. The separation of the fruit spurs exposes the nymphs to the dust.

TABLE 1

Mean numbers of spittle masses

Treatment	Percent	Spittle masses per 100′ of row	
		Mean No.	Mean (Transformed)
Heptachlor	2.5	14.1	3.80
Aldrin	2.5	18.7	4.37
Chlordane	5.0	29.1	5.43
DDT	5.0	90.1	9.51
Check (Untreated)		203.7	14.29
L.S.D. ($P < 0.05$) for Check vs. any Treatment			6.09
L.S.D. ($P < p.05$) for Between Treatments			2.81

Stitt and Allmendinger (1954) found that chlordane gave better control of the spittlebug on strawberries than did methoxychlor, rotenone, TDE, or a combination of DDT and parathion. They were attempting to develop an economical control of both spittlebugs and the omnivorous leaf tier, two pests that often occur at the same time. Root weevils are also a pest of strawberries in western Washington and perhaps a control program could be devised that would include this pest as well. The season of 1953 was greatly retarded. The flower buds on the strawberries were still closed and the fruit spurs had not yet separated.

The following dusts were applied on May 12 and 13 with a duster driven by the power takeoff on the tractor: aldrin 2.5 percent, chlordane 5.0 percent, DDT 5.0 percent and heptachlor 2.5 percent. Each plot consisted of 12 rows approximately 240 ft. long. Each treatment was replicated five times. The duster was set to give adequate coverage and applied about 20 lbs. to the acre.

Counts were made on June 17 and 18 to determine the number of spittle masses on the plants in 100 ft. of row. Two 100-foot sections were taken from near the centers of the middle rows in each replica. All spittle masses in these sections were counted. Since there were five replicas, data were taken from 1000 ft. of row for each treatment. The data have been summarized in table 1. The spittle mass counts were transformed, using the formula $\sqrt{x+3/8}$, prior to performing the analysis of variance. It will be noted that aldrin and heptachlor were effective

controls for spittlebugs on strawberries in western Washington when applied under the conditions described. As already stated, it had been shown that chlordane was a satisfactory control for spittlebugs; however, when aldrin and heptachlor were tested in comparison with chlordane, they gave somewhat better control.

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THE OHIO FLORA PROJECT

At a meeting of the Executive Committee of the Council of the Ohio Academy of Science in December, 1950, it was agreed that the preparation of an "Ohio Flora" would be a significant contribution to Ohio science and a worthy project for the Academy to sponsor. A committee was appointed and began functioning in March, 1951. The general plan is that the "Ohio Flora Committee" of the Academy will direct this project and solicit aid from Ohio field botanists and taxonomic specialists in and outside Ohio.

As stated in an earlier note[1] these plans were announced at the Academy meetings at Miami in April, 1951. The response of Ohio botanists was splendid. Questionnaires distributed at that time led to the location of many thousands of herbarium specimens available for study. Each year, as the project becomes better known, much has been added to the known herbarium resources. Even as late as April, 1954, (Athens meeting of the Academy) two significant plant collections were made known and available to the committee. It is the purpose of this note to inform Ohio scientists of progress being made and also to locate additional botanical and human resources. Botanists, amateur or professional, who have a collection or know of a collection which is not already participating in this project are asked to contact a member of the committee. Botanists who are in a position to do plant collecting in Ohio may also contribute to the study. The committee would be happy to accept specimens or records of specimens collected.

As is now planned, the "Flora of Ohio" will contain all vascular plants, native and naturalized, known to occur in Ohio. It will contain keys, diagnostic and habitat notes and distribution maps (by counties) for all species. In order to have the records of maximum value, help is needed from every possible source.

In order to assembly information and to facilitate further study of actual specimens we are asking for a herbarium slip (a printed form provided by the committee) for each specimen. Many thousands of such slips have already come in; more come in each month.

The size of this project seems to warrant an installment plan approach. A special effort was made to collect herbarium slips for all woody plants. On the basis of these records Dr. Braun prepared a preliminary list of the woody plants of Ohio. This 45-page mimeographed publication lists over 400 species. The county distribution for each species is reported as shown by the herbarium slips. More than 100 copies of this list were distributed early in 1953. As a result, a great amount of collecting has been done in an effort to fill the gaps in distribution records. A copy of this publication may be obtained from the secretary. Ultimately, a bulletin on the "Woody Plants of Ohio" will be published.

Present work going on includes a manuscript being prepared on the *Crataegus* of Ohio by Dr. E. J. Palmer, (specialist on this difficult genus). Dr. C. R. Ball, a specialist on willows, is almost as far along with work on the genus *Salix*. Dr. Wm. G. Gambill, Jr., Ohio University, is now working on a preliminary list of the Ohio legumes. Even as this is written Dr. Clara Weishaupt, The Ohio State University, is preparing a preliminary list of the grasses of Ohio, and at New Concord, Professor William Adams is preparing a similar list of Ohio Pteridophytes. These lists will be available from the secretary when completed and will be sent to all who are on our mailing list.

The general plan is that preliminary lists of special groups will be mimeographed and distributed free to all interested parties. Such lists will reveal the need of more collecting. After a year or two of such collecting and reporting, a printed segment of the "Ohio Flora" should be available. We hope to publish shorter installments of the "Ohio Flora" in this journal and others as bulletins of the Ohio Biological Survey. Ultimately, the many segments should be revised and assembled as a single volume. This is years, and thousands of man-hours, away.

COMMITTEE ON A "FLORA OF OHIO."

J. ARTHUR HERRICK, *Secretary, Kent State University, Kent, Ohio*
E. LUCY BRAUN, *Chairman, 5956 Salem Road, Cincinnati 30, Ohio*
GLENN W. BLAYDES, *The Ohio State University* JOHN N. WOLFE, *The Ohio State University*
EDWARD S. THOMAS, *The Ohio State Museum* CLARA WEISHAUPT, *The Ohio State University*

[1]E. L. Braun, et al., (1952). Flora of Ohio. Ohio Jour. Sci. 52: 34.